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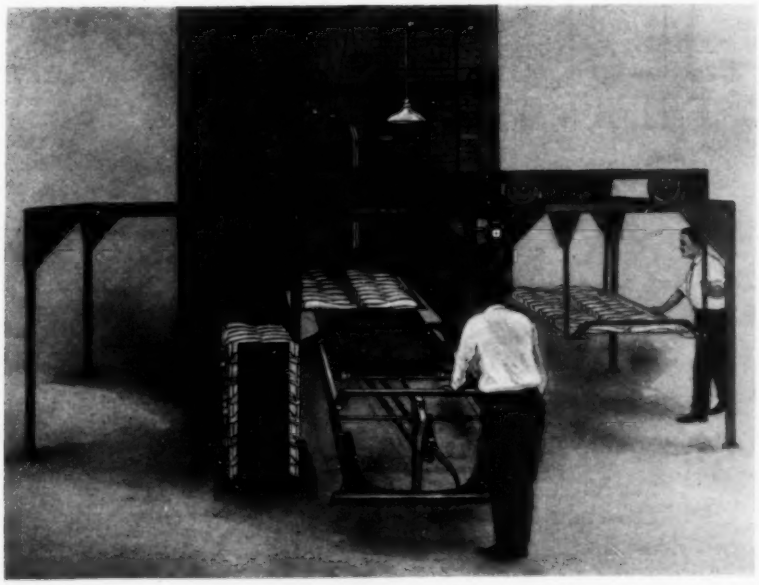

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ORIGINAL PAPERS

FURTHER STUDIES ON CAST GLASS POTS

BY R. F. GELLER[1] AND A. N. FINN

ABSTRACT

This paper is a progress report covering the work done by the Bureau of Standards during the past three years on the problem of cast glass pots. The work done is essentially an application of the results of research reported in previous Bureau publications and contains data on body compositions, the arching of pots and their resistance to optical glass. The following conclusions were made: (*a*) The casting of porcelain glass pots has passed the experimental stage; (*b*) The content of plastic clay is not of prime importance as long as the body will cast satisfactorily; (*c*) Proper watersmoking practically eliminates fissures and surface cracks; (*d*) Pots should be arched to the highest temperature consistent with the refractoriness of the body.

The present paper is essentially a progress report of investigations on the problem of cast porcelain glass pots, continued during the past three years by the Bureau of Standards. Previous publications of the Bureau[2] on this subject have covered in a comprehensive manner the results of generally accepted physical tests on various compositions, and also detailed procedures for casting. The laboratory results have been of great value in formulating desirable bodies, and the method for casting, as originally suggested, has remained unchanged except for engineering details.

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] F. H. Riddle, *Jour. Amer. Ceram. Soc.*, **2** [8], 647 (1919); J. W. Wright and D. H. Fuller, *ibid.*, **2** [8], 659 (1919); D. H. Fuller, *ibid.*, **3** [7], 569 (1920).

It was felt, however, that the investigation required the application of the data obtained. The opportunity to do this is found in the Bureau itself where the history of the pot can be recorded by technically trained observers from the mixing of the raw batch to the breaking away of the pot shell from the finished glass.

The casting apparatus which has been installed in the Laboratory of the Industrial Building (see Fig. 1) has a capacity of three pots daily and is practically the same as that suggested in a previous publication[1] of the Bureau.

Body 332, as given in Table I, is the same as body number 6 of the

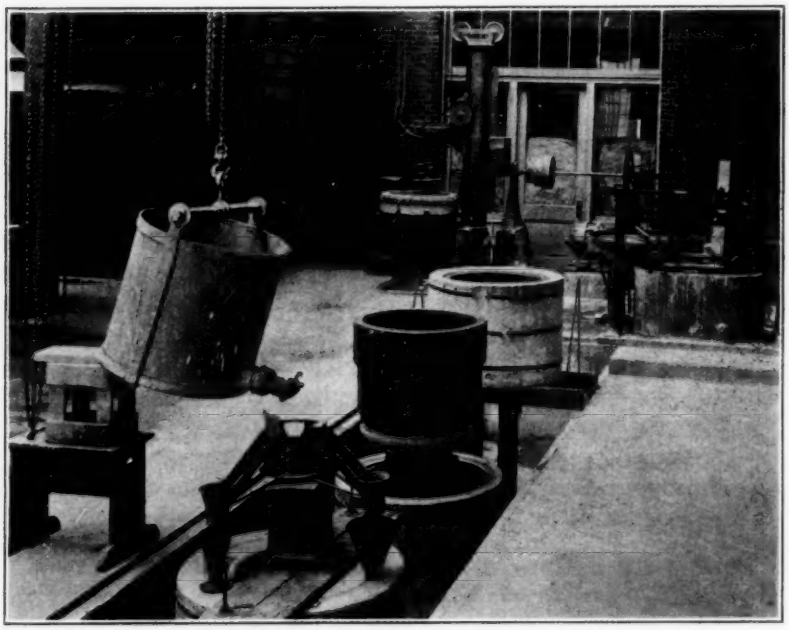


FIG. 1.

paper by D. H. Fuller. This body was one having desirable qualities, as evidenced by laboratory tests, and was largely used in the work covered by this report.

As is evident from the table, bodies 332,334 and 6 of this paper are essentially the same, the only variation being found in the composition of the grog. Body D was designed to produce a dense structure by means of a higher ball clay and fine grog content rather than with feldspar and bodies A and B were designed to study the effect of eliminating kaolin from the bond.

[1] F. H. Riddle, *loc. cit.*

TABLE I

BODY COMPOSITIONS

	Body Number					
	332 %	334 %	6 %	A %	B %	D %
Feldspar	6	6	6	2	2	4
Tenn. ball clay No. 5	10	10	10	35	35	16
Ky. ball clay No. 4	10	10	10	7	7	9
N. C. kaolin	12.5	12.5	12.5	..	..	12
Del. kaolin	4.5	4.5	4.5	..	..	4.5
Ga. kaolin	4.5	4.5	4.5	..	..	4.5
Flint	..	..	..	24	24	..
Grog	52.5	52.5	52.5	32	32	50

GROG COMPOSITIONS

Tenn. ball clay		19[1]	50[1]	50[1]	35[1]	50[1]
N. C. kaolin		19	50	50	35	50
Whiteware bisque	100	62	..	..	30	..

GROG SIZING

10 to 20-mesh	35	35	35	35	20	20
20 to 40-mesh	45	45	45	45	50	50
Through 40-mesh	20	20	20	20	30	30

[1] Calcined to cone 10.

The deflocculating agent generally used in casting the pots consisted of sodium carbonate and sodium silicate. The carbonate varied from 0 to 80 parts per 100 parts of silicate. Excellent casts were also obtained by means of sodium silicate, sodium carbonate and gallic acid in the ratios of 100:8:8. This ratio could be varied to 76:8:32 without apparently affecting the casting properties, but as the gallic acid was increased above this amount the slip gradually became lifeless and would not cast successfully. The total amount of deflocculating agent used varied from 0.15% to 0.21% of the dry weight of the batch, the amount depending on the per cent of plastic material in the body.

The deflocculating agent is added to the water in the blunger before the clay is introduced and, after thoroughly blunging the entire batch, the quality of the slip is judged by its "feel." That is, the laborer in direct charge can tell after a little experience approximately how much additional water to use by the way the slip runs off his fingers. His observation is then checked by determining the specific gravity of a sample. The blunger is usually charged about 8:30 A.M. and the blunging continued until 3:30 P.M. when the slip is ready for casting. The core is withdrawn at 8:00 A.M. the following morning and twenty-four to thirty hours later the shell is lowered away from the pot. It is then ready for "slicking," after which it is carefully dried. The pot is then placed in a pot arch

TABLE II

Pot number	Body number	Melt number	Sp. gr. of slip	Arching Max. temp. °C	Arching Time held at max. temp. (in hours)	Type of glass	Remarks
15	334	424	1.94	1300	5	Boro-silicate	Bottom badly fissured
16	334	425	1.94	1300	5	Boro-silicate	Bottom badly fissured
17	334	426	1.93	1300	5	Boro-silicate	Pot O. K.
20	334	428	1.92	1300	5	Lt. Barium Crown	Leaked through a small hole. Probably a casting flaw
24	334	429	1.92	1300	5	Lt. Barium Crown	Pot O. K.
26	332	433	1.91	1300	5	Lt. Barium Crown	Small cracks
27	332	435	1.92	1300	5	Boro-silicate	Bottom fissured
29	332	434	1.92	1300	5	Lt. Barium Crown	Pot leaked
30	332	...	....	....	..	....	Cracked in arching
31	332	436	1.92	1300	5	Lt. Barium Crown	Bottom fissured
32	332	445	1.93	1300	5	Boro-silicate	Pot O. K.
33	332	438	1.92	1300	5	Barium Flint	Bottom fissured
34	332	437	1.93	1300	5	Medium Flint	Bottom fissured
37	332	441	1.92	1300	5	D. Barium Crown	Leaked badly. Compare with Pots 55 and 76
39	332	443	1.92	1300	8	Boro-silicate	Bottom fissured
41	332	446	1.90	1300	10	Boro-silicate	Pot O. K.
49	332	454	....	1300	8.5	Medium Flint	Porosity: side, 19.4; bottom 20.9
50	332	455	....	1260	10	Boro-silicate	Porosity: side, 19.0; bottom 21.2
51	332	456	....	1350	12	Medium Flint	Porosity: side, 16.4; bottom 18.3
52	332	459	....	1400	5	Lt. Barium Crown	
53	332	457	....	1350	8	Medium Flint	Glass attack 1/4" in bottom. Porosity: 16.7%

TABLE II (*Continued*)

54	332	458	....	1400	8	Medium Flint	Pot O. K. Porosity: 11.6%
55	332	460	....	1400	8	D. Barium Crown	Shows glass attack along fissures
58	332	464	....	1435	3	Dense Flint (1.65)	Pot leaked
61	332	466	....	1450	6	Boro-silicate	Pot bottom buckled due to high arching temperature. Porosity 11.2%
62	332	465	....	1450	6	Dense Flint	Pot O. K.
64	332	469	....	1400	8.5	Boro-silicate	Cracked during cooling
65	332	472	....	1400	6.5	Boro-silicate	Same as Pot 64
68	332	474	....	1425	7	L. Barium Crown	Pot O. K.
69	332	475	....	1425	7.5	Medium Flint	Pot O. K.
70	332	467	....	1450	4.5	Dense Flint	Bottom of pot buckled slightly due to high temp. O. K. Porosity 12.2%
72	332	468	....	1450	2	Medium Flint	Gallic acid used in casting. Pot O. K. Porosity 9.4%
73	332	477	....	1430	1	Boro-silicate	Pot O. K.
74	6	478	....	1425	8	Light Crown (soda lime)	Pot O. K.
75	6	479	....	1425	8	Boro-silicate	Pot O. K.
76	A	480	1.81	1425	16	D. Barium Crown	Slight penetration
77	A	481	1.85	1425	8	Boro-silicate	Pot O. K.
78	B	482	....	1425	8	Very Dense Flint	Slight penetration
80	B	483	....	1425	8	Light Crown	Pot O. K.
83	6	485	1.87	1425	9	Light Crown	Pot O. K.
84	6	486	1.90	1425	7	Boro-silicate	Pot O. K.
85	D	487	1.88	1425	17	Light Crown	Pot O. K.
87	D	488	....	1425	8	Boro-silicate	Pot O. K.

resting on 3 brick piers to permit a free circulation of furnace gases around it. According to present practice it is heated very slowly to 300°C and at an increased rate to 1425°C, as per the following schedule:

12 hours at 75°
12 hours at 100°
3 hours from 100–150—hold 9 hours
3 hours from 150–200—hold 9 hours
3 hours from 200–250—hold 9 hours
3 hours from 250–300—hold 9 hours
35 hours from 300–825 (15° per hr.)
24 hours from 825–1425 (25° per hr.)
8 hours at 1425°

When the burning is completed the pot is transferred from the pot arch to the hot melting furnace.

The temperature in the pot arch is measured by means of a thermocouple introduced through the crown. The couple is protected by means of a sillimanite tube of sufficient length to bring the end of the couple about 6 inches inside the furnace.

Approximately one hundred pots have been cast by the method outlined above and no failures have occurred except those resulting from the use of a mold which is too dry or a body of modified composition. The first cause of failure, due apparently to unequal or too rapid absorption of water from the slip, is usually overcome by one cast. The trouble may be caused either by a new mold or by an old mold which has not been used for some time. Preliminary wetting of the mold seems to result in unequal absorption of water by the plaster. In either case the pot develops serious cracks while in the mold. The second cause of failure is not serious and one cast is sufficient to determine the proper amount of deflocculating agent and water; or, as is sometimes the case, to determine whether or not the body is of proper composition to form a slip which will cast at all.

Table II contains, in abridged form, a summary of observations on forty-four pots cast and used by the Ceramic Division in the manufacture of optical glass. Data on twenty other pots, used in the making of borosilicate glass, is omitted since they were satisfactory in every way although small surface cracks had developed in the bottoms during the burning.

As is evident from the table, pots 15 to 49 inclusive were practically of the same composition and since they were burned in the same way, the only variable introduced is the type of glass used. It is to be noted that only the barium crown glasses (see pots 20, 29 and 37) caused serious trouble. In every other melt of this group the pots were quite satisfactory but not entirely so, because in no case can it be said that they were free from attack. In many cases the structure of the pot was fissured and showed well defined laminations which acted as lines of least resistance

for the glass attack. The porosities determined on specimens of pot 49, after the melt, are probably typical of this group.

The second group, from numbers 50 to 73 inclusive, were burned in the pot arches at the slower rate previously outlined, and to higher temperatures. The effect of higher arching on the final porosity is evident from the following:

Pot no.	Max. temp.	Time held	Mean porosity
49	1300	8.5	20.1
50	1260	10.0	20.1
51	1350	12.0	17.3
53	1350	8.0	16.7
54	1400	8.0	11.6
61	1450	6.0	11.2
70	1450	4.5	12.2
72	1450	2.0	9.4

There was also a very evident improvement in the structure of the pots and their resistance to glass attack. The body is denser, as evidenced by the decrease in porosity, and the tendency to form fissures is practically eliminated.

Results indicate that the best burning can be obtained in a pot arch, and the generally accepted procedure of burning pots in the melting furnace or of arching to 800–1000°C and then finishing the burn in the melting furnace, is not satisfactory since such treatment cannot burn the pot bottom thoroughly.

Pot 55 was the only exception noted. Pot 53 showed appreciable glass attack, but it had a fairly high porosity due to the low arching temperature. Melt 464 (pot 58) was blocked[1] repeatedly and it is possible that this treatment exaggerated an incipient strain in the pot which resulted in the leak.

It was evident from observations on the pots that the body of which they are composed is not sufficiently refractory to stand a temperature above 1435°C for any length of time in the pot arch, without more or less deformation. The buckling was noted on the bottoms of the pots at the three points of support.

In the last group of melts there are two main variables to be considered—the pot composition and the type of glass. The dense barium crown, and a very dense flint glass (see pots 76 and 78) penetrated the pot body

[1] Blocking consists of forcing a small amount of ammonium nitrate on the end of an iron rod through the glass to the bottom of the pot. The nitrate explodes almost immediately, stirring up the glass, and the force of such repeated explosions, especially under a glass of high density, may be sufficient to weaken the pot. Blocking is especially desirable in glasses containing lead oxide which is exceedingly corrosive and which, on account of its low melting point and high density tends to segregate at the bottom of the pot.

slightly. The balance of the pots were to all appearances perfect in their resistance to corrosion and fissuring. Bodies A and B are particularly worthy of note because their composition varied radically from any tried heretofore, but this variation in composition did not affect the resistance to glass attack. They did shrink excessively in burning, which was to be expected because of the high ball clay content. Body A for example, carried a total of 67% ball clay of which 25% was introduced in the grog and 42% in the bond. Four high ball clay pots have been used to date, all of which were very satisfactory regardless of the fact that two of them were used for the most corrosive glasses.

The work of the past three years on cast porcelain pots for optical glass seems to justify the following conclusions.

1. The casting of porcelain pots has passed the experimental stage and has become a matter of plant routine requiring very little if any technical control.
2. The ball clay and kaolin content is not a vital factor as long as the slip will cast properly and form a body of dense and homogeneous structure.
3. Slow burning to about 300° practically eliminates fissures and surface cracks.
4. Pots should be arched to the highest temperature consistent with the refractoriness of the body.

SOME CAUSES OF BLISTERING OF SHEET STEEL METAL ENAMELS[1]

By George F. Comstock

ABSTRACT

This paper gives the results of a metallographic investigation of some samples of defective white enameled ware, the peculiarities of the steel underlying the defects having been examined through the microscope. Two distinct kinds of defects were recognized, one of which, characterized by dark spots arranged in streaks, was found to be due to foreign inclusions in the steel. It was concluded that the other defect, consisting of irregularly scattered spots, was most probably due to gas absorption during pickling, the ultimate cause lying either with the pickling process or the steel quality. Detailed descriptions and photomicrographs are given of the structures and inclusions in the steel bases of the samples examined.

Through the kindness of B. T. Sweely, Chairman of the Enamel Division of the American Ceramic Society, the author had an opportunity to study with his microscope the structural peculiarities of the steel under-

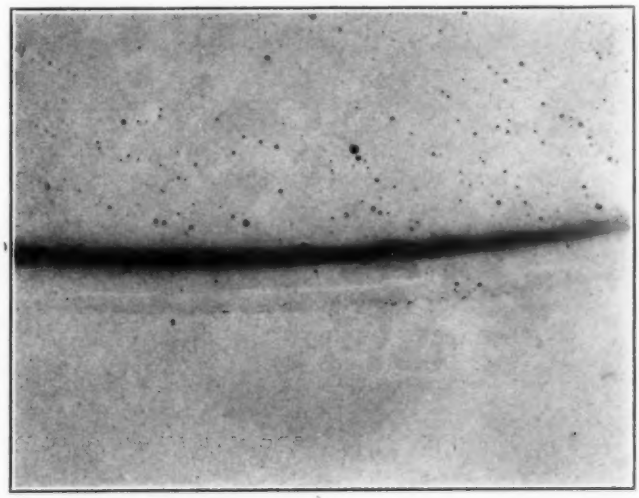


Fig. 1.—Natural size view of side of tea-kettle Sample 6, showing defective upper part with streaks of dark spots, and good lower part without spots.

lying certain defects on white enameled ware. The results of this study, on eight samples of ware, representing two distinct types of defect, are reported in this paper.

The nature of the defects studied is illustrated by Figs. 1 and 2. All consisted of black spots in the white enamel, the spots varying from mere discolorations to open craters like broken bubbles where the steel

[1] Read before the Enamel Division, Pittsburgh Meeting, Feb., 1923.

appeared almost bare. Fig. 1 illustrates one type in which the spots were arranged in streaks which evidently would have been straight and parallel to each other had the steel sheet not been distorted to form the

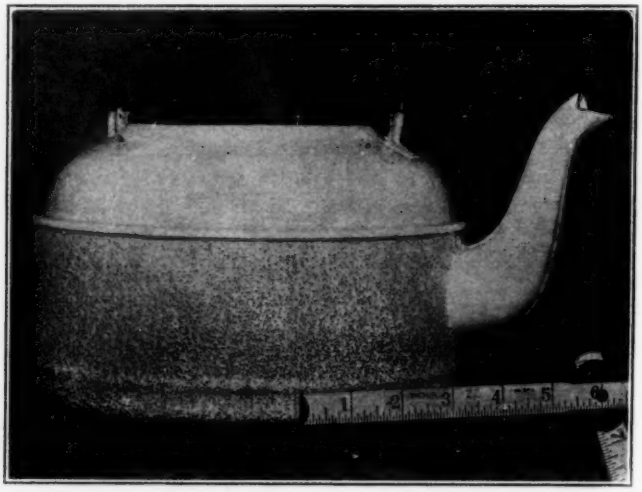


FIG. 2.—Tea-kettle Sample 8, showing extremely defective lower part, with good upper part and spout.

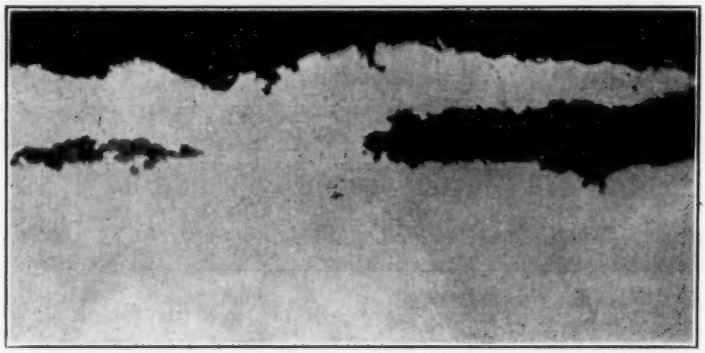


FIG. 3.—Edge of section of the pail, at a defective spot, showing enamel above and steel below, with gray oxide inclusions in the steel at the left. At the right the enamel has penetrated into a larger oxide inclusion.

curved surfaces of the ware. Fig. 2 illustrates the other type in which the spots were irregularly scattered more or less evenly all over the surface.

FIG. 3.—Unetched sections, magnified 200 diameters, of samples showing defective spots arranged in streaks.

Fig. 2 is a tea-kettle, composed of an upper part welded onto a lower part made from a different sheet. This, it is believed, proves that the cause

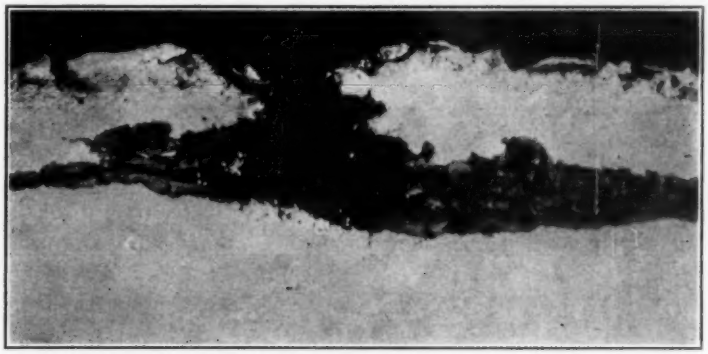


FIG. 4.—Another view of same specimen as FIG. 6, showing a spot where the enamel has penetrated through a thin layer of steel into a long thin oxide inclusion near the surface of the steel.

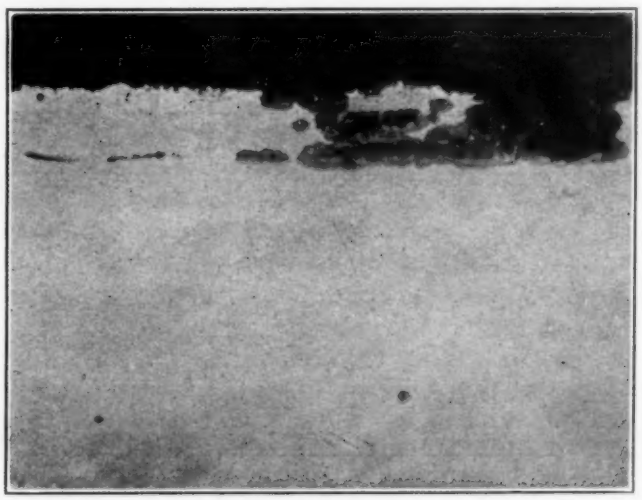


FIG. 5.—Edge of section through upper part of tea-kettle Sample 6, at one of the streaks of defects. The dark gray enamel is shown at the top, and extending down into an oxide layer in the steel. Note the thin slag inclusions at the left of the light-gray oxide.

of the defect did not lie in the temperature of firing the enamel but in the sheet steel.

FIGS. 4, 5.—Unetched sections, magnified 200 diameters, of samples showing defective spots arranged in streaks.

For the metallographic study, numerous sections were cut through the samples at both good and defective locations, and were packed in bundles of four, with red-fiber between them, for polishing. The four sections of enameled ware, with red-fiber between, and brass ends, formed approximately a rough cube, one face of which was polished. In this way per-

FIG. 6.—Edge of section of small kettle, at a defective spot, showing enamel above and steel below, and two thin oxide inclusions in the steel just below the surface.

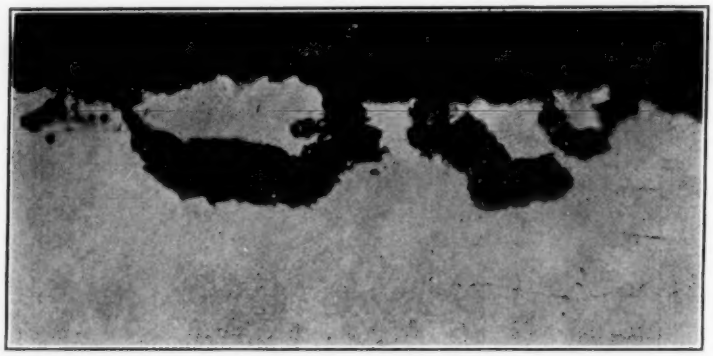


FIG. 7.—Another view of same specimen as FIG. 6, showing penetration of the enamel into the steel with hardly any indication of pre-existing oxide inclusions. Note fine crack or oxide streak near lower right-hand corner.

fectly flat sections of the thin samples could be made smooth enough for examination. The enamel however caused considerable trouble, for it could not be entirely cracked off the steel, and neither could it be retained entirely in the polished sections during the preliminary grinding because

FIGS. 6, 7.—Unetched sections, magnified 200 diameters, of samples showing defective spots irregularly scattered.

its brittleness caused fragments of it to break away continually below the surface of the metal. Thus the steel strips in the polished surface were not uniformly supported along their edges, but depressions existed where pieces of enamel had broken away, and it was impossible to prevent the soft steel from flowing into these depressions to a certain extent during the grinding and polishing. The edges of the steel sections, when examined in the microscope after polishing, appeared for this reason somewhat more rough and irregular than they should be.

All the samples in which the defects occurred in streaks showed the same peculiarities on examination of the polished sections before etching. At places that were not defective the steel appeared normal and fairly clean, but the sections cut through the defective streaks showed slag and oxide

FIG. 8.—Section of defective lower part of tea-kettle Sample 7, showing some of the thin erratic oxide streaks extending down into the center of the sheet.

inclusions in the steel a short distance below the surface of the sheet. The smaller slag inclusions did not seem to have affected the enamel, but the large oxide masses had been in many cases entered by the enamel and these undoubtedly were the cause of the defective spots noted on the surface of the ware. These oxide masses were very similar to inclusions that have been found to have caused blisters in tin-plate and galvanized sheets, and they are believed to be due to scale rolled into cracks in the ingot during manufacture of the steel sheet. In forming the ware from the

FIG. 8.—Unetched sections, magnified 200 diameters, of samples showing defective spots irregularly scattered.

sheet of steel, the oxide mass was evidently shattered, and in many cases the thin layer of metal above the oxide inclusion was probably ruptured. This permitted access of the pickling acid to the included oxide, and later when the enamel was applied and burned on, it also ran down into the oxide and reacted with it, evolving the gases that produced the bubbles or black specks in the white enamel.

Several photomicrographs show the peculiarities of the samples having this type of defect. The enamel is shown very dark in comparison with the steel because in the microscope the illumination is purely vertical, and under this condition the polished metal reflects light much more efficiently than the partially transparent enamel. Iron oxide when polished is intermediate in reflecting power and hence appears light gray in the

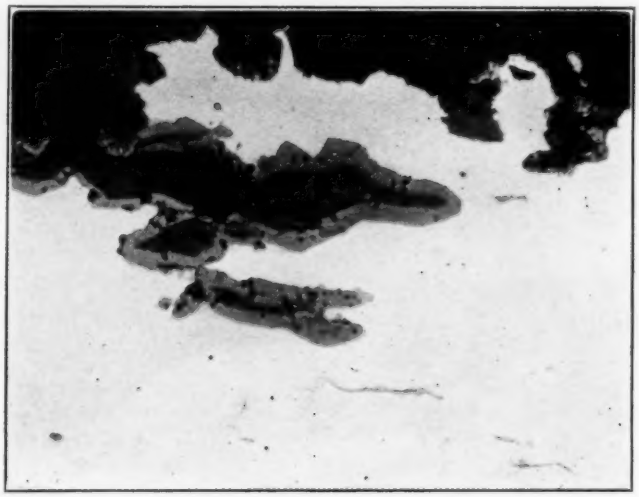


FIG. 9.—Section of defective lower part of tea-kettle Sample 8, showing one of the spots where excessive penetration of the enamel occurred, with oxide streaks also down in the center of the sheet.

photomicrographs, but silicate or slag inclusions in steel appear dark like the enamel.

The irregularly scattered defects were studied in the same way. At some of these defects oxide inclusions were found a short distance below the surface of the steel, but they were not nearly as large as those found in connection with defects of the other type. There were many places where the enamel seemed to have penetrated into the steel without any evidence of oxide inclusions having occurred there beforehand, but in most

FIG. 9.—Unetched sections, magnified 200 diameters, of samples showing defective spots irregularly scattered.

instances of enamel penetration there was considerable formation of oxide around the included masses of enamel. In one of the tea-kettle samples this enamel penetration was particularly severe, extending down to the

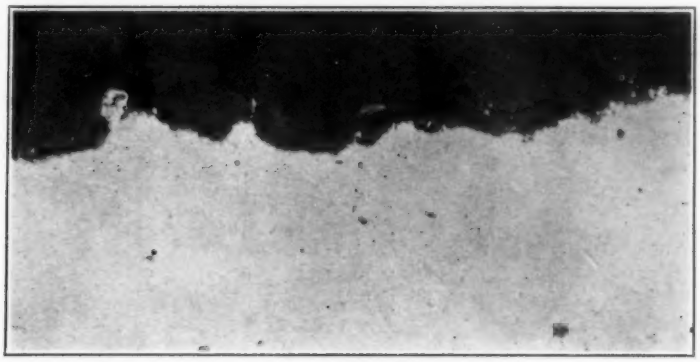


FIG. 10.—Edge of section of oval foot-tub where no defects occurred, showing fairly clean steel and fragments of cracked enamel above it.

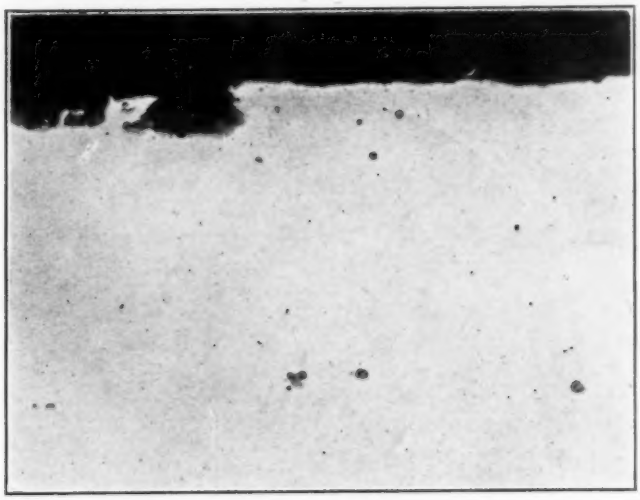


FIG. 11.—Section of good upper part of tea-kettle Sample 8, showing very slight enamel penetration at the edge, and a few small slag and alumina inclusions in the steel.

center of the sheet in many places. In another, iron oxide occurred in thin irregular and erratic streaks extending sometimes to the center of the section. These thin streaks resembled the intergranular cracks that

FIGS. 10, 11.—Unetched sections, magnified 200 diameters, at good parts of the samples, where the enamel showed no defects.

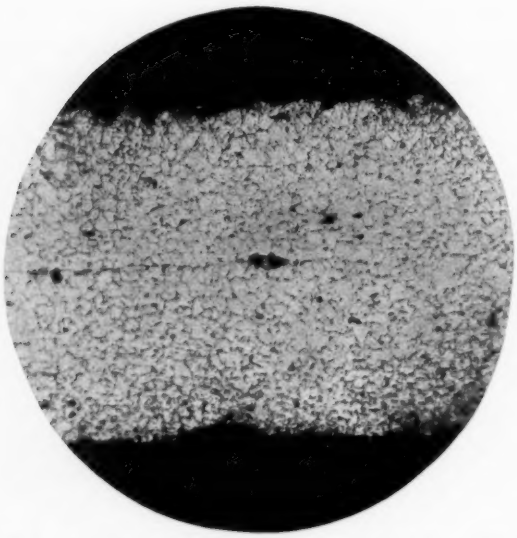


FIG. 12.—Fine and even structure of steel in oval foot-tub, but showing traces of slag along center line of the sheet.

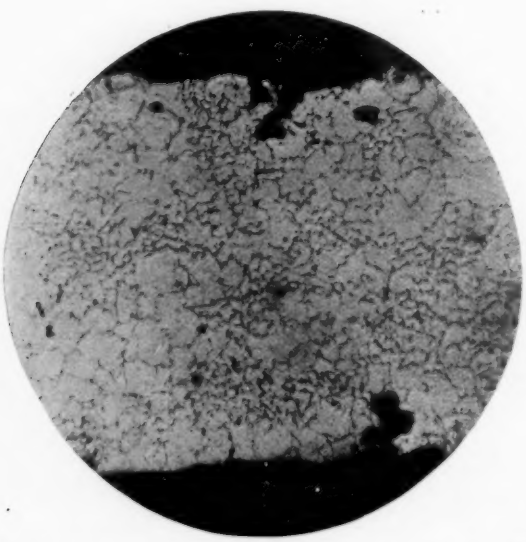


FIG. 13.—Coarse, uneven structure of steel in small kettle, with penetration of enamel at edges of the sheet.

FIGS. 12, 13.—Sections etched with nitric acid and magnified 100 diameters. The black strips at top and bottom of each print are space beyond the edges of the sections.

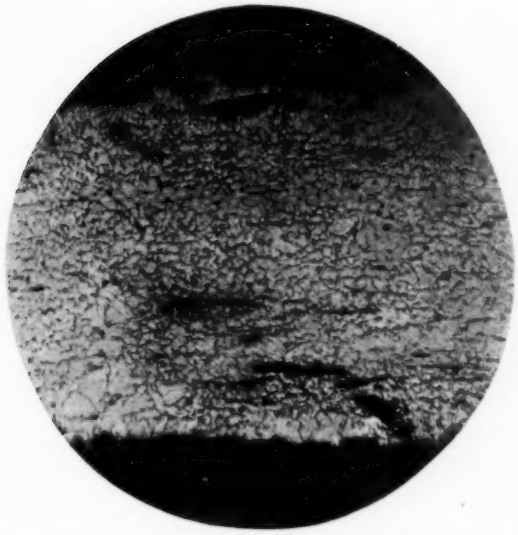


FIG. 14.—Uneven structure, with some coarse grains, in the basin showing elongated dark streaks, apparently cracks, in some of which near the edge the enamel has penetrated.

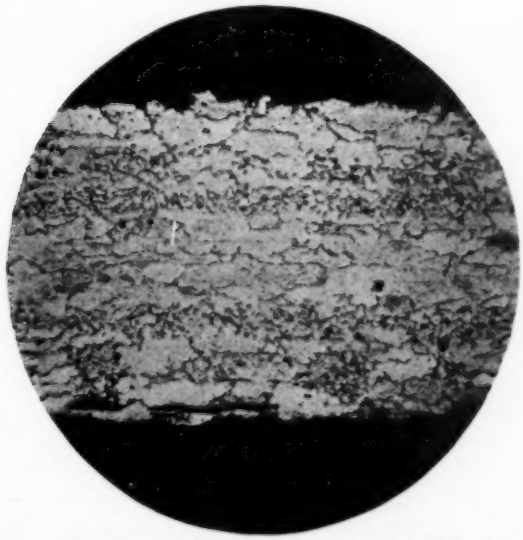


FIG. 15.—Coarse elongated structure of defective upper part of tea-kettle Sample 6, showing fine sorbite particles unevenly distributed, the center of the sheet being almost without sorbite.

FIGS. 14, 15.—Sections etched with nitric acid and magnified 100 diameters. The black strips at top and bottom of each print are space beyond the edges of the sections.

have been found in brass articles which failed from "season cracking." No defect like this could possibly have originated in the ingot or sheet-bar without being much more elongated in the rolling of the sheet, and it does not seem possible that these streaks could have existed before spinning the ware without failure of the material during that operation.

The parts that were not defective in these samples showed slight enamel penetration with oxide at a few scattered points on the edges of the specimens. The interiors of these good specimens contained scattered angular slag particles, or in some instances alumina, and there was no evidence that such small scattered slag particles in the interior of the sheets had any relation to the defects on the enameled surfaces.

The photomicrographs illustrate the inclusions and enamel penetration in the samples showing the second type of defect, and in a good sample, just as the previous photomicrographs illustrated the first type. All the photomicrographs of unetched sections were taken at a magnification of 200 diameters.

The specimens were all etched with nitric acid to reveal their microstructure, which was characterized by ferrite grains differing in size and uniformity, with particles of sorbite scattered more or less evenly within and between them. The carbide was present in the form of sorbite because of the rapid cooling through the critical range when the enamel was baked. Some of the samples with the streaky type of defect had good fine structures, so that although one of them showed a poor, segregated structure, this could not be considered important in connection with the defects. In the same way with the other type of defect, some of the good samples had poorer microstructures than some of the spotted samples, and no definite connection was indicated between the structure and the defects. A few photomicrographs are shown to illustrate some of the structures of the etched specimens, magnified 100 diameters. The principal observations made on each sample during the microscopic work are noted briefly in the following table:—

Sample	Defect	Inclusions in metal	Microstructure
Oval foot-tub, 1	Spots in streaks	Oxide and slag near surface	Fine and even
Pail, 2	Spots in streaks	Oxide and slag near surface	Fine and even
Upper part of tea-kettle, 6	Spots in streaks	Oxide and slag near surface	Coarse, uneven, and banded
Small kettle, 3	Scattered spots	Enamel penetration	Uneven, rather coarse
Basin, 5	Scattered spots	Enamel penetration	Uneven (fine cracks?)
Lower part of tea-kettle, 7	Scattered spots	Intergranular oxide streaks and enamel penetration	Fine and even
Lower part of tea-kettle, 8	Scattered spots	Intergranular oxide streaks and enamel penetration	Fine and even

Pitcher, 4	None	Alumina	Rather coarse but even
Lower part of tea-kettle, 6	None	A little slag	Coarse and uneven
Upper part of tea-kettle, 7	None	Clean	Coarse and uneven
Upper part of tea-kettle, 8	None	A little slag and alumina	Coarse, with sorbite all at grain boundaries

As has been noted above, the cause of the spots arranged in parallel streaks on some of the samples may be assigned quite definitely to the presence of scale or oxide rolled into cracks in the steel during manufacture of the bar or sheet. The cause of the defect that took the form of spots scattered irregularly all over the enamel is much more obscure. It is obvious, as has been noted, that it cannot lie in the heating during firing of the enamel, since these samples included two instances of an article being made up of parts of different sheets, one of which showed a large number of defects while the other showed none. The microscope did not reveal any distinctive structure in the metal of the defective samples, but showed marked enamel penetration into the steel, and in the worst cases some apparently intergranular streaks of oxide that suggested "season cracks."

In view of all the facts that have been determined in this study, the most plausible explanation of the irregularly scattered defect appears to be that there was excessive corrosion and gas absorption in the defective samples during the pickling process that intervened between the forming and the enameling of the ware. On this assumption the penetration of the enamel and even the intergranular streaks of oxide may be explained, for it is known that under certain conditions of strain in metals, chemical action upon them may take the form of pitting and intergranular attack, leading to separation of the crystals, instead of a uniformly distributed surface action. The fissures produced by such action on the steel during pickling would naturally become oxidized in drying, and when heated in baking the enamel they would become filled with the fused oxide and enamel. Pickling is also known to cause absorption of gas in proportion to its severity, so that the evolution of this gas from over-pickled material by bubbling through the enamel when it is baked on the steel might be expected.

The restriction of the defects in the tea-kettles 7 and 8 to their lower parts is readily explained on the above theory by assuming a different chemical composition of the two pieces of steel used for each kettle. It must be admitted that there is nothing improbable in this assumption. If two pieces of steel of different composition are joined as they were in these tea-kettles and subjected to acid attack, the attack will be largely

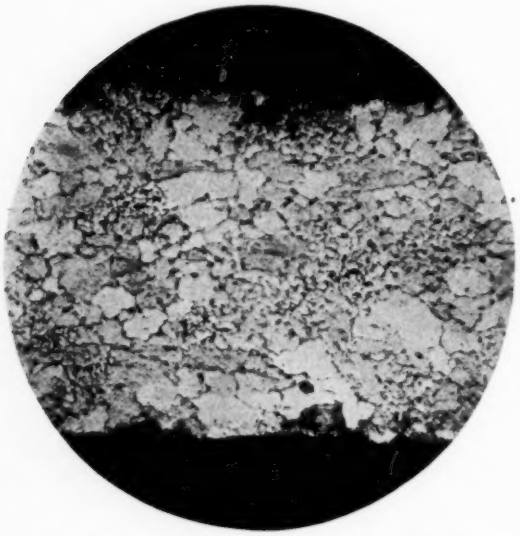


FIG. 16.—Coarse structure, and uneven distribution of sorbite, in the good upper part of tea-kettle Sample 7.

FIG. 17.—Fairly fine and even structure of the defective lower part of tea-kettle Sample 8, showing excessive enamel penetration.

FIGS. 16, 17.—Sections etched with nitric acid and magnified 100 diameters. The black strips at top and bottom of each print are space beyond the edges of the sections.

confined to that piece whose electrolytic potential, as determined by its composition, is the greatest. In these instances the solubility of the lower pieces was evidently considerably greater than that of the upper, so that the pickling required for proper cleaning of the latter was entirely too much for the former.

It was thought that possibly the greater resistance of the upper part of sample 8, for instance, to the pickling as compared with the lower part might be due to the former being copper-bearing steel. Chemical analysis, however, showed 0.10% copper in the lower part and 0.035% copper in the upper part, so that neither steel was commercially copper-bearing. According to the usual experience with copper in steel, the lower part should have been more resistant to acid attack, but other exceptions to the general effect of copper have been found and it does not seem that these copper contents differed sufficiently to contradict the theory outlined above. It has at least been shown that the two sheets used for sample 8 were not of the same chemical composition, and probably differences in some of the elements not determined would account for the different action of the sheets in pickling.

The significant difference may not even lie in the elements usually determined in steel analysis, but may be in the content of some gas, such as oxygen or nitrogen, or some oxide such as MnO. It was shown by G. A. White in "A Metallurgical Study of the Steel Base as Related to Galvanizing" that absorption of hydrogen in pickling became excessive and gave trouble in galvanizing when a certain form of manganese oxide was present in the steel, and that aluminum oxide caused the same trouble. Titanium-treated steel, however, which was "free from dissolved gases and oxides," gave good results in galvanizing. It is very probable that the results in enameling are governed by the same factors, and would be similarly improved by the use of a steel base of a more uniformly high quality, which would not suffer excessive pitting and gas absorption during the pickling operation.

TITANIUM ALLOY MFG. COMPANY
NIAGARA FALLS, NEW YORK

SOME INVESTIGATIONS ON KILN BURNING

By Robert M. Campbell

This investigation which I helped to carry out was conducted similarly to those investigations made by R. T. Stull formerly of the U. S. Bureau of Mines, who made some very valuable contributions toward the more efficient burning of the heavier clay wares. The real purpose of our work was to increase the efficiency of the burning in three ways: to reduce the time to burn, to conserve fuel, and to improve the quality of the ware.

The investigation was a comparison of two burnings. The brick burned were the vertically scored buff burning No. 2 fire clay brick which are the standard product of this plant. The first burn was made with no change in construction of the kiln, method of setting, or firing. The kiln was operated as was the practice at the yard. In the second burn no change was made to the kiln but the water-smoking period was cut down while the oxidation and soaking periods were decreased somewhat.

The data to be obtained on the kilns to be investigated was:

(*a*) Dimension of kilns (including flues, dampers and stacks)
(*b*) Quantity of ware set, method of setting and dryness of ware when set
(*c*) Quantity of fuel used
(*d*) Sampling and analysis of fuel
(*e*) Temperature (top–middle–bottom)
(*f*) Determination and rate of water-smoking
(*g*) Analysis of flue gas
(*h*) Determination and end of oxidation
(*i*) Frequency of firing and cleaning of fires
(*j*) Quantity of ash
(*k*) Sampling and analysis of ash
(*l*) Sampling of clay
(*m*) Sample of ware
(*n*) Data for heat balance

The kiln investigated was a round down draft kiln of 32 feet inside diameter. It had eight stacks built in the wall with openings (9 × 12). There were eight slanting bar furnaces, commonly known as Dutch furnaces. There was a main flue with eight flues, one leading to each stack and the floor had a "pigeon hole" bottom. The kiln was old and in rather poor condition, leaking air. Due to expansion the walls at the bottom were crowded out and probably the stack openings were reduced. The brick set were the standard buff burning brick. They were flat set and were wet, the mechanical moisture being 3.4%. Coal from the company's own mine was used. It was high in sulphur and clinkered badly. Every eight hours the fires were cleaned, that is after the water-smoking period.

Here is given the analysis of both the coal and clay:—

Analysis of coal		Analysis of clay	
Moisture	0.34	Silica	64.84
Volatile Carbon	28.75	Alumina	25.45
Fixed Carbon	60.32	Iron Oxide	2.87
Ash	10.59	Titanium Oxide	1.44
Sulphur	2.36	Calcium Oxide	0.20

B.t.u. (Cal. value)	13,462	Magnesium Oxide	0.90
Color of ash	Purplish Gray	Alkalies	3.62
		Loss on Ignition	0.72
		Fusion Cone 27	3038°F

By the analysis of the flue gas one is enabled to determine the amount of excess air a kiln uses. Should a kiln use too little air the fuel will not burn to complete combustion thus causing a waste of coal. If the percentage excess air is too great all that in excess is needlessly heated up and so is responsible for a good bit of the lack of efficiency. A sample of the flue gas was taken each half hour throughout the burn and for twenty-four hours a day. The gas was collected directly from a pipe inserted in the stack. This particular kiln was of the multiple stack type so half the sample was taken at one flue and the remaining half at that flue on the opposite side of the kiln. The gas was collected in a bottle over water and analyzed by the use of an Orsat for the percentage composition of the three gases carbon dioxide, oxygen and carbon monoxide. The Orsat is not difficult to operate but in steady use the different solutions which absorb the different gases must be replenished from time to time. Records were kept of the temperature, the presence of moisture in the flues which was determined by inserting in the flue a piece of glass, the condition of the dampers, the amount of coal consumed and any general remarks such as the state of the fires, the presence and color of smoke at the stack, etc. No sample of the gas was taken immediately after firing.

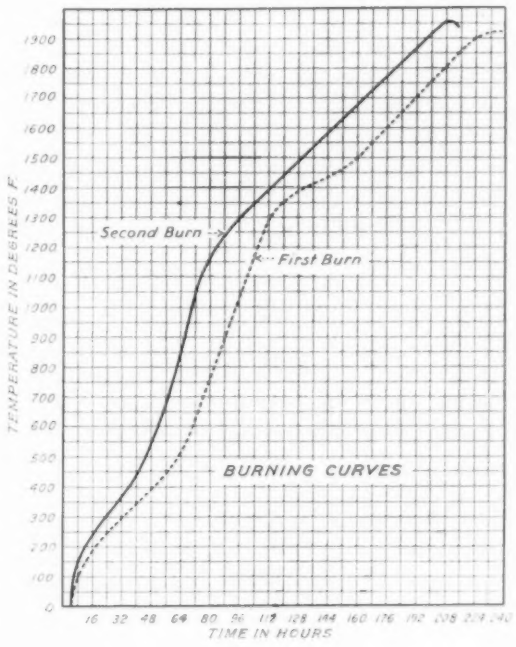


FIG. 1.

Below are the burning periods as they were taken:

Water-smoking	Up to 650°F
Dehydration	650 to 1100
Oxidation	1100 to 1700
Soaking	1700 to 1950

TABLE I

FIRST BURN

Percentages—Excess air

		CO_2	O_2	CO	(CO_2, O_2, CO)	N_2	$3.78 \times O_2$	Diff.	$\frac{N}{Diff.}$
	Max.	3.2	18.4	0.5	22.1	77.9	68.6	9.3	837.5
Water Smoking	Min.	1.0	15.8	.0	16.8	83.2	59.7	23.5	354.0
	Av.	1.84	17.5	.18	19.52	80.48	66.2	14.28	564.0
	Max.	4.3	18.0	0.5	22.8	77.2	68.0	9.2	839.0
Dehydration	Min.	1.7	13.1	.0	14.8	85.2	49.5	35.7	239.0
	Av.	3.12	16.3	.13	19.55	80.45	61.5	18.95	424.5
	Max.	8.5	18.3	0.3	28.0	72.0	69.2	2.8	2570.0
Oxidation	Min.	1.5	9.5	.0	10.5	89.5	35.9	53.6	167.0
	Av.	4.03	14.9	.07	19.0	81.0	46.3	34.7	233.5
	Max.	11.2	15.8	0.7	27.7	72.3	59.7	12.6	573.0
Soaking	Min.	4.0	7.0	.0	11.0	89.0	26.5	62.5	142.2
	Av.	7.6	10.2	.13	17.93	82.07	38.6	43.47	189.0

Formula used: $\frac{N}{N-(3.78-O_2)} = R, \frac{R-I}{R} \times 100 =$ Per cent excess air,

TABLE II

SECOND BURN

Percentages—Excess air

		CO_2	O_2	CO	(CO_2, O_2, CO)	N_2	$3.78 \times O_2$	Diff.	$\frac{N}{Diff.}$
	Max.	4.2	18.7	0.4	23.3	76.7	70.7	6.0	1279.0
Water Smoking	Min.	1.3	14.5	.0	15.8	84.2	55.8	28.4	296.3
	Av.	2.7	16.7	.17	19.57	80.43	63.1	17.33	462.5
	Max.	5.0	17.6	0.4	24.0	76.0	66.5	9.5	800.0
Dehydration	Min.	2.0	13.7	.0	15.7	84.3	51.8	32.5	259.2
	Av.	3.25	16.1	.23	19.58	80.42	60.86	19.56	411.0
	Max.	8.6	18.5	0.4	27.5	72.5	69.9	2.6	2790.0
Oxidation	Min.	1.3	12.1	.0	13.4	86.6	45.7	40.9	212.0
	Av.	3.8	15.6	.12	19.52	80.48	58.97	21.51	374.0
	Max.	10.1	18.3	0.5	28.9	71.1	69.2	1.9	3740.0
Soaking	Min.	1.6	8.4	.0	10.0	90.0	31.8	58.2	154.5
	Av.	5.5	13.7	.14	19.34	80.66	51.79	18.87	428.0

Formula used: $N-(3.78-O_2) = R, \frac{R-I}{I} \times 100 =$ Per cent excess air.

Sheet No. 1.—Method of computing per cent excess air explains the maximum, minimum, average, etc. CO—tells if there is complete combustion or not. 3.78—a ratio of nitrogen to oxygen by vol.).

Sheet No. 2.—Same as No. 1 but calculations for second burn.

Sheet No. 3.—Clearly shows the comparison between the two burnings as to brick set, length of time to burn, coal consumed, per cent excess air, etc.

Sheet No. 4.—These burning curves graphically represent the comparison of the length of time to burn of the two burnings as compared to the temperature in degrees F.

Sheet No. 5.—Heat balance as figured out for the first burn. Efficiency $\frac{\text{Heat out}}{\text{Heat in}}$.

TABLE III

RESULTS OF TESTS OF THE TWO BURNINGS ON KILN NO. 2

	First burn	Second burn	Difference	Per cent G. Or
No. Brick Set	66,000.00	62,800.00	3,200.00	4.85
Length of Burn, Hrs.	235.00	212.00	23.00	9.70
Total Coal, Lbs.	133,253.00	79,960.00	60,293.00	45.17
Coal per M. Brick, Lbs.	2,019.00	1,161.80	857.20	42.45
Coal per ton Ware	689.10	396.50	282.60	42.46

Per cent excess air	First burn Max.	First burn Min.	First burn Av.	Second burn Max.	Second burn Min.	Second burn Av.	Difference Max.	Difference Min.	Difference Av.	Per cent G. Or Max.	Per cent G. Or Min.	Per cent G. Or Av.
Watersmoking	837.5	354.0	564.0	1279	296.3	462.5	441.5	57.7	101.5	152.6	16.3	18.0
Dehydration	839.0	329.0	424.5	800	259.2	411.0	39.0	20.2	13.5	4.6	6.9	3.2
Oxidation	2570.0	167.0	233.5	2790	212.0	374.0	220.0	45.0	140.5	8.5	26.9	60.3
Soaking	573.0	142.2	189.0	3740	454.5	428.0	3167.0	12.3	239.0	553.0	8.6	126.5

	First burn	Second burn	Difference	Per cent G. Or
Coal-Watersmoking	27,206.10	19,253.00	7,953.00	29.23
Coal-Dehydration	9,056.60	11,527.00	2,471.00	27.29
Coal-Oxidation	61,396.60	25,840.00	35,556.00	59.70
Coal-Soaking	35,593.30	16,340.00	19,253.00	54.08

Hours	First burn	Second burn	Difference	Per cent G. Or
Watersmoking	70.0	49.0	21.0	30.0
Dehydration	25.0	26.0	1.0	4.0
Oxidation	92.0	84.0	8.0	8.7
Soaking	48.0	53.0	5.0	10.4

The heat in is the amount of fuel in lbs. × calorific val. The heat out is that heat energy which actually goes to heat up the product set in the kiln. It is determined in three steps:

B.t.u. required to bring the ware and water to steam formation
B.t.u. required to change water to steam
B.t.u. required to heat from temperature of steam formation to the maturing temperature.

Conclusion

Records made and kept in this form clearly show the comparison of the burnings and thereby help in the regulating of the kiln to make it more efficient in conserving fuel, and in the length of time to burn.

HEAT BALANCE—KILN No. 2

Started: July 6, 1922, at 6 P. M.
Finished: July 16, 1922, at 12 N.
Set with 66,000 shale flashed brick
Coal used: 133,253 lbs.—66.63 tons
Calorific value of fuel: 13,462 B.t.u.
Weight of green brick: 5.86 lbs.
Water to evaporate in 1 brick—0.2 lbs.

(1) 5660 (weight of 1000 brick) × (212−72) 792,400 B.t.u. Required to raise the temperature of 1000 brick to temperature of steam formation.

Average setting temperature—72

1000 × 0.2 = 200 lbs. water in 1000 brick

(2) 200 × (212−72) = 28,000 B.t.u. Required to raise the temperature of 200 lbs. of water to temperature of steam.

(3) 200 × 980 (Latent heat of steam) = 196,000 B.t.u. required to change 200 lbs. of water to steam

(4) 5560 × (1970−212) = 9,950,280 B.t.u. required to raise the temperature of 1000 brick from 212 to 1970

792,400 B.t.u. (1)
9,950,280 B.t.u. (4)

(5) 10,742,680 B.t.u.

Specific heat of clay 0.2

(6) 10,742,680 × 0.2 = 2,148,536 B.t.u.

28,000 B.t.u.
196,000 B.t.u.
2,148,536 B.t.u.

2,372,536 B.t.u. Total required per 1000 brick.

133,253 ÷ 66,000 = 2019 lbs. coal used for 1000 brick

2019 × 13,462 = 27,179,778 B.t.u.

$$\text{Efficiency} = \frac{\text{Heat out}}{\text{Heat in}} = \frac{2{,}372{,}536}{27{,}179{,}778} = 8.69\%$$

ALFRED, N. Y

THE SUITABILITY OF THE TUNNEL KILN FOR BURNING REFRACTORIES[1]

By A. F. Greaves-Walker and S. M. Kier

The final report of the Committee on Fuel Conservation on Tunnel Kilns has been delayed longer than expected due to the desire to gather all data possible, especially from European sources, but principally because it was desired, if possible, to have some practical burning tests made on silica brick. As all efforts in this direction have failed, the Committee has decided to submit the following report of the work accomplished and their conclusions.

Since issuing the preliminary report[2] the Committee has visited one plant operating a tunnel kiln burning refractories. This kiln is located at the plant of the Ohio Valley Clay Company, Steubenville, Ohio, and is a Dressler.

The kiln is 303 feet 6 inches long and the cross section approximately 4 by 6 feet. It will hold 47 cars each 6 feet long.

Natural gas is used for burning and cone 12 is hooked in center of cars. The entering air has a temperature of 200°F and the exit air 250°F. The maximum charging rate is 2 hours.

The high heat zone is 75 feet long. The lining throughout is Mt. Savage fire brick. Repairs have been very low during the five years of operation, the kiln having been built in 1917–18. The approximate cost was $120,000 at a period of high costs.

The car repairs have been very low. Refractory car tops last approximately one year.

This kiln is used exclusively for the burning of fire clay shapes, many of which are large and would be classed as difficult. This accounts for the 94-hour burning time. It is practically impossible to figure the capacity of this kiln in 9 inches equivalent or to compare its output with that of the average fire brick plant.

It is safe to say, however, that no more difficult ware is made on any refractories plant in the world and as the losses are practically nil it may be assumed that any type of product made of flint clay—calcine—bond clay mixtures could be handled safely under the same conditions.

Investigation of the European situation reveals the fact that the Germans and French consider the tunnel kiln as perfectly successful for burning fire clay refractories of any type or kind. Installations are numbered by the dozens. This has naturally led to an attempt to develop kilns for burning silica, magnesite and chrome.

[1] Presented at the Tenth Annual Meeting of the Refractories Manufacturers Association, March 23, 1923, New York City.

[2] See "Preliminary Report of the Committee on Fuel Conservation on the Railroad Tunnel Kiln," *Jour. Amer. Ceram. Soc.*, **5** [9], 602 (1922).

There are, at the present time, two kilns being operated on silica brick entirely and two under construction as a result of the success of the first two.

The operating kilns are at the plant of Dr. Otto and Company at Bendorf, Rhein and are known as Otto kilns. Dr. Otto is the well known by-product coke oven builder and operates his own refractories plants.

The first Otto kiln was started in 1913 and was originally 100 meters long. This was found to be too short and it was extended from time to time, principally on the cooling end until in 1919 it had reached a length of 160 meters or 528 feet. A second kiln was built in 1921 of this same length which would indicate that the first was successful.

These kilns are burning silica brick and shapes used almost exclusively in coke oven construction, made from Westerwald quartzite and burned to cone 14. The Westerwald quartzite is a flint or chert and of an entirely different type from those of Pennsylvania and Wisconsin.

An attempt has been made to keep the results obtained from these kilns secret and as a result details are not obtainable. It is known, however, that the product is going into coke ovens and that laboratory tests show the brick to be equal to those burned in down-draft kilns. It is interesting to note that these kilns are operated with producer gas without preheating.

Conclusions

From the investigations made the Committee feels safe in concluding that the tunnel kiln has been developed to a point where it will burn fire clay refractories of any type equally as well as down-draft kilns. These conclusions are based on the results being obtained on the Didier-March, Farber and Ohio Valley kilns and on tests on refractory products in the Champion Porcelain Company's kiln at Detroit, which is operating at cone 18. We have also the results obtained on European operations over a long period of years. It would, of course, be necessary to design a kiln especially for each operation after careful tests of the raw material and mixes and the establishment of a burning curve.

As to the question between the muffle and open type kilns, it is the Committee's conclusion that the open type will burn any fire clay refractories successfully that can be burned in the muffle type and vice versa. First cost would, therefore, naturally govern in the selection.

The question of capacity is an important one. No kiln, as far as the Committee can learn, has been built which produces over 18,000 9-inch equivalent per 24 hours. This is not considered the limit, however, in the present stage of development. From observation of kilns burning other products it is believed that kilns could be built that would successfully burn from 30,000 to 32,000 per 24 hours at cone 12 to 14. It is

very largely a question of total length of kiln, length of high fire zone, fuel used, and method of burning fuel.

In order to produce 32,000 9-inch brick per 24 hours burned at cone 12 the following general specifications would apply.

Length of Kiln—360 feet
Car 7′ 6″ long
$\frac{360}{7.5}$ = 48 cars in kiln

Time of burning—72 hours
72 ÷ 48 = 1½ hours charging rate
24 ÷ 1.5 = 16 cars per day
2000 brick to car × 16 = 32000 brick per day

This is, of course, entirely theoretical, but several recognized kiln engineers, who have been consulted, agree that the 30,000 capacity kiln is now possible.

As to the feasibility of successfully burning silica refractories in tunnel kilns the Committee thinks that it is possible. It is being done in Europe although at lower temperatures. As was to be expected the problem was one of cooling rather than one of heating up and burning. Cone 18–20 temperatures do, however, present a problem when a large output of product is required. The burning of silica brick is not only a question of bond, but one of inversion which introduces a time factor. It requires exposure to a certain temperature for a certain length of time to produce a commercial silica brick and the only way in which this period can be shortened is to use higher temperatures. For this reason brick now being burned at cone 18 would have to be burned at cone 20 if the burning time was reduced. To produce the necessary volume of heat to burn any considerable number of silica brick would require either a long burning zone or regenerators, which means high construction costs. Furthermore, the inversion points during the cooling period must be taken into consideration in the kiln design.

On account of the size of the average silica brick plant in this country it is not practical to consider a kiln which would produce less than 24,000 9-inch equivalent per day. This is relatively a small unit, but it is questionable whether a tunnel kiln of the standard design could be economically built and operated, which would have larger capacity.

The theoretical specifications for a 24,000 capacity kiln would be as follows:

Length 540 feet
Cross section 5 ft. × 6 ft. effective
Car 7½ feet long
$\frac{540}{7.5}$ = 72 cars

Burning time 6 days = 144 hours
$\frac{144}{72}$ = 2 hour charging rate
$\frac{24}{2}$ = 12 cars per day
2000 brick to car × 12 = 24000 brick per day

It is of course, possible that a much larger output could be obtained by building a longer kiln and charging cars at one hour periods, but the car capacity would have to be reduced to 1,500 brick or less.

Such a kiln would theoretically have to be 715 feet long and would produce from 30,000 to 35,000 9-inch per day.

The burning curve on such a kiln would be as follows:

Advance	Drop
40 hours at 20° per hour	7 hours at 20° per hour
19 hours at 65° per hour	13 hours at 123° per hour
18 hours at 20° per hour	15 hours at 40° per hour
	4 hours at 20° per hour
77 hours	39 hours

Total 116 hours

A much shorter kiln could be used and the capacity probably increased by making use of the regenerative principle. Designs for such a kiln have been submitted to the Committee and have received very favorable consideration. In this kiln two lines of cars moving in opposite directions are burning at the same time and the use of regenerators makes it possible to build up temperatures in a manner impossible in the standard design. This kiln being designed on entirely new principles, so far as the tunnel kiln is concerned, it is impossible for the Committee to say more than that it is worth the consideration of those interested.

The question of the best fuel to use in connection with a tunnel kiln burning refractories has been given consideration.

In Europe producer gas is used almost exclusively. This is probably due to the possibility of using low grade fuels, such as brown coal, in this manner. Experience in this country also indicates that producer gas is entirely successful.

Producer gas has some disadvantages, however. The deposit of tar and soot in the flue system makes it necessary either to build a double flue system or shut the kiln down and "burn out" periodically. "Burning out" may be necessary every six days or only every thirty days according to the fuel used and the method of operating the producer. The operation requires from 2 to 6 hours depending on the deposit and length of flue system. This is not a serious disadvantage.

A new system recently developed by the Cottrell Company may successfully solve the problem of soot and tar in producer gas. In this system these troublesome ingredients are precipitated electrically and the gas passes through the flue perfectly clean. This would reduce its heating value somewhat unless the precipitated soot and tar could be returned to the producer.

Another disadvantage which may or may not be serious according to the raw material used is that reducing conditions obtain unless special attention is paid to preventing them.

With the application of stokers to tunnel kilns the use of coal has be-

come very efficient and the question of handling it made easy. Methods of using preheated air for secondary combustion have been devised which also adds to the efficiency of coal fuel although this applies equally to producer gas.

It appears that the question of fuels is largely a matter of personal choice. Little need be said about the fuel saving advantages of the tunnel kiln. Other industries have found that they can wipe out their old burning systems and replace them with profit. The report on one tunnel kiln which went under fire six months ago and which cost $50,000 to build, showed that their saving on fuel alone the first year would amount to $60,000. As the percentage saving on fuel would be the same in one industry as another, it is logical to presume that the refractories' industry would average a saving of at least 75%.

SILICA CEMENT[1]

By E. N. McGee

ABSTRACT

Composition, requirements and specifications for first quality silica cement are discussed. Adequate control tests for determining its suitability are described, together with such investigations as have been made for the purpose of obtaining a satisfactory cement.

The latter part of the paper deals with the bonding qualities. An investigation showed that the use of molasses greatly improved the bond without affecting the refractoriness.

Introduction

This subject is one which has received little attention, and yet its importance should not be underestimated. The proper selection of a cement or fire clay for laying up brick is just as important as the selection of the brick itself, and should receive as careful and rigid inspection. One of the most important characteristics of silica brick, as has been previously mentioned in several articles, is its ability to resist deformation under load at any temperature below its softening point. It is then obvious that in laying up silica brick, the use of a mortar which may decrease the refractoriness of the brick is injurious, because it affects this characteristic of silica brick, and defeats the purpose for which they are used. Silica brick should, therefore, be laid up with a mortar as nearly like the brick in composition as possible, and still possess suitable working and bonding properties. In a great many instances it would appear that the consumer does not know the character of silica cement nor how to determine its suitability. In fact it seems to be a somewhat general opinion that all silica cements are essentially the same, manufactured in the same manner, and consequently any will answer the purpose satisfactorily.

It is the purpose of this paper briefly to outline the requirements and suitable methods for testing the quality of silica cement, together with such investigations as have been made for the purpose of obtaining a satisfactory cement.

Composition of Silica Cement

Silica cement is usually manufactured of ground silica brick bats with sufficient plastic clay added to give it the proper plasticity and bonding qualities. It is essential that the plastic clay used shall be refractory, of fairly high silica content and that only a sufficient quantity be added to produce the desired results, which is usually about 25%. The proportioning of the clay and bats is usually done mechanically as they go to the mixers, and they are then ground together in the mill to the desired fineness.

[1] Read before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

Some manufacturers substitute raw or unburned ganister rock for part of the silica bats, making the mixture of approximately the following proportions:

50% silica bats
25% ganister rock
25% plastic clay

The fact that the ganister rock expands upon being subjected to heat and will tend to offset the shrinkage of the plastic clay is undoubtedly the chief reason for its use. There is, however, some basis for the claim, as will be shown later, that the addition of the rock also appears to increase the refractoriness of the cement.

There are, then, only two things to be considered in the manufacture of silica cement—*viz.* quality and proportion of plastic clay to be used, and fineness of grind. If ganister rock is used, it is also customary to fix the amount necessary to offset the shrinkage of the plastic clay.

Requirements

Refractoriness is the main requisite of a good silica cement for high temperature requirements, and it should not be impaired even at the expense of the other properties. The cement should not soften at the working temperatures even though it does not flow out of the joints. It should be sufficiently refractory so that it not only meets the requirements of ordinary working conditions, but should also if possible, stand up under any abnormally severe conditions, which may be met. It is absolute folly to build a furnace for high temperature requirements in which the mortar used for laying up the brick is materially inferior to the brick itself. If the mortar fuses or softens and runs out of the joints, it invariably causes a reaction with the brickwork, which is detrimental to its refractoriness. It also leaves open joints, which render the brickwork more readily attacked by flame and more subject to spalling action. For low temperature requirements, if the bonding properties are more important than refractoriness, it may be justifiable to decrease the refractoriness, but even then it is necessary to take into consideration the safety factor, to allow for abnormal conditions. The lower the fusion point of the cement the more detrimental will be the chemical action on the silica brick caused by its fusion.

Next to refractoriness in importance comes plasticity. Silica cement should be sufficiently plastic to possess the necessary working qualities in order that it may spread easily and smoothly with a trowel. It should not settle out or become sandy in the mortar boxes if left standing for several hours. It should possess sufficient bonding qualities to stay in place and hold the brickwork together during the drying and heating up periods. The percentage of plastic clay, which should be used is mainly

dependent upon the character and quality of the plastic clay. This clay should be highly siliceous and refractory, having a fusion point of about Orton cone 28–1635°C.

The working qualities are also in measure dependent upon the fineness of grind. If the cement is rather coarse it will not spread easily and requires a higher percentage of plastic clay to make it stand up in the mortar boxes. It is, therefore, advisable to have the cement ground fine, considerably finer than fire clay because it does not possess the inherent plasticity and the mixing with water cannot break down the grains of silica bats or ganister rock.

The requirements of silica cement are therefore refractoriness, fair plasticity, fair bonding qualities and fineness.

Testing of Silica Cement

On account of the important character of this material, and the great possibility of its varying in quality, it is generally advisable to test each car load of the cement. A representative sample should be taken at the manufacturer's plant before shipment so that the tests will be completed, and the quality of the cement determined, if possible, by the time the car has reached its destination. The following tests are those usually employed in determining the suitability of this material.

Refractoriness.—The refractory quality is most readily obtained by determining the fusion point as described in method C 24–20 of the American Society for Testing Materials. This test is accurate, simple in operation and quickly determined. The fusion point of first quality silica cement should not fall below Orton cone 28–1635°C. The softening point of silica brick lies between Orton cones 31 and 32, but the addition of plastic clay decreases this to some extent, depending upon the percentage used and its refractoriness. Obviously the lower the refractoriness of the plastic clay the less that can be used without producing a cement which fluxes at a temperature below that which actual practice has proved satisfactory.

The following data shows the effect of the percentage of plastic clay upon the fusion point of a silica cement.

TABLE I

Per cent ground silica bats	Per cent plastic clay	Fusion point of cement
100	0	Cone 31+
90	10	Cone 31—
80	20	Cone 30
75	25	Cone 29
70	30	Cone 28
65	35	Cone 27–28
60	40	Cone 26–27

Actual fusion point of the plastic clay used in this investigation was cone 27. These mixes were made in the laboratory, and consequently variation in quality of plastic clay or silica bats is entirely eliminated. The results, therefore, should be representative and fairly accurate.

Another investigation carried out on a very large scale at the plant of the United States Refractories Corporation seems to indicate that the substitution of raw ganister rock for the silica bats has a tendency to increase the refractoriness of the cement. In an investigation on such a large scale as this, there may be a small variation in the percentage of clay in the mixers, and there may also be a variation in the quality of the clay itself. The results were, however, very consistent as is shown by the following data. The fusion point determinations were made at the Mellon Institute of Industrial Research.

TABLE II

Per cent plastic clay	Per cent silica bats	Per cent raw ganister rock	Fusion point of cement
25	75	0	Cone 26–27
25	50	25	Cone 28
25	37½	37½	Cone 30
25	0	75	Cone 31½

Fineness.—The fineness of a silica cement may be determined by sifting dry in a sieve-shaking machine of the Ro-tap type for ten minutes. The automatic time stop and mechanical shaking give accurate results if the sample is dry and the sieves are standard and clean. It is important that the cement should be fine in order to provide the proper working qualities, and to allow for the proper laying up of the bricks with thin joints. The Semet-Solvay specifications require that the cement shall be of such fineness that approximately all will pass a 30-mesh screen conforming to the United States Bureau of Standards Specification. Size of opening .0223 inch, diameter of wire .011 inch. We also use the 40-, 60-, 80-, 100- and 200-mesh screen on this test.

The following are actual sifting tests on various silica cements as received from three different manufacturers at the Testing Laboratory of the Semet-Solvay Company.

TABLE III

SILICA CEMENTS

	1	2	3	4	5	6
Through 30-mesh screen	99.4%	99.5%	99.0%	99.7%	99.8%	100%
Through 40-mesh screen	96.8	97.5	93.6	99.5	94.5	99.6
Through 60-mesh screen	75.8	69.9	68.4	90.7	66.1	80.6
Through 80-mesh screen	65.0	59.9	56.5	82.0	54.9	71.6
Through 100-mesh screen	58.7	54.0	49.3	71.3	47.1	62.0
Through 200-mesh screen	44.0	39.8	35.7	48.1	28.7	36.7
Fusion point in cones	28–29	28–29	30	20–26	29	29

Practically 100% of each of these cements pass the 30-mesh screen and consequently they would be acceptable as far as that test is concerned. The fusion point of cement No. 4 is, however, slightly low and would be just cause for its rejection.

3. Analysis.—In a special case like silica cement, a chemical analysis is of considerable value because it not only shows the composition, but also can be used in determining the percentages of plastic clay, which the cement contains, and thus indirectly gives an indication of the plasticity of the cement. The calculation of the percentage of plastic clay is based upon the alumina contents of the silica cement and the plastic clay. If the plastic clay does not vary greatly in quality this method will give fairly accurate results. The following proportion is used to obtain the percentage of clay.

Per cent Al_2O_3 of the clay: (% Al_2O_3 of the cement—1%) :: 100% clay : x% clay in the cement.

One per cent Al_2O_3 (introduced by the silica bats) is subtracted from the Al_2O_3 of the cement. The remainder is the Al_2O_3 obtained from the clay.

The following chemical analyses of a plastic clay and silica cements, with their actual softening point determinations, illustrate the use made of these tests.

TABLE IV

	Plastic clay	Silica cement 1	Silica cement 2	Silica cement 3
SiO_2	63.96%	84.62%	83.40%	82.00%
Al_2O_3	23.64	7.56	8.90	10.00
Fe_2O_3	2.32	3.12	2.61	2.40
CaO	.24	1.45	1.55	1.35
MgO	.58	.18	.19	.28
Alkalies	3.73	1.33	1.35	1.54
Loss on ignition	5.88	2.02	2.30	2.62
Total	100.35	100.28	100.35	100.00
Fusion point in Cones	20	26	20–26	19
Per cent Plastic Clay by Al_2O_3 calculation		27.7	33.5	38.1

Example—23.64 : 6.56 :: 100 : x
23.64 x = 6.56
x = 27.7% Plastic Clay

It is interesting to note that the relations between the per cent plastic clay and the fusion points of these silica cements given in Table V (which are samples from car load shipments) are practically identical with the relative values given in Table I, which was a laboratory investigation. The data in Tables IV and V also bear out the statement previously

TABLE V

	Plastic clay	Silica cement 1	Silica cement 2	Silica cement 3
SiO_2	77.48%	90.04%	89.60%	89.02%
Al_2O_3	15.80	4.88	5.66	6.00
Fe_2O_3	.64	1.12	.96	.90
CaO	.26	2.24	1.96	1.85
MgO	.24	.20	.20	.22
Alkalies	.64	.39	.40	.42
Loss on ignition	5.32	1.44	1.60	1.78
Total	100.38	100.31	100.28	100.19
Fusion point in cones	27	29	28	27–28
Per cent Plastic Clay by Al_2O_3 calculation		24.5	29.5	31.6

made that the higher the percentage of plastic clay in a silica cement, the lower will be its refractoriness.

Plasticity.—If the fusion point and fineness tests prove satisfactory it is then only necessary to know whether or not the cement contains a sufficient amount of plastic clay to give it the proper working and bonding qualities. The pail test, which the Semet-Solvay Company uses for this purpose is simple and adequate. The cement is mixed with water to the consistency of dipping mortar and allowed to stand eighteen hours. If after this time it has not settled so as to cake in the bottom of the pail, experience shows that it will spread smoothly, and easily, and not give trouble by settling in the mortar boxes.

Another simple test is also usually made by buttering the cement between the flat surfaces of two 9-inch straight brick, and allowing it to thoroughly air-dry. The cement should then support the lower brick when the upper brick is suspended with the joint in a horizontal plane.

Bonding Qualities of Silica Cement

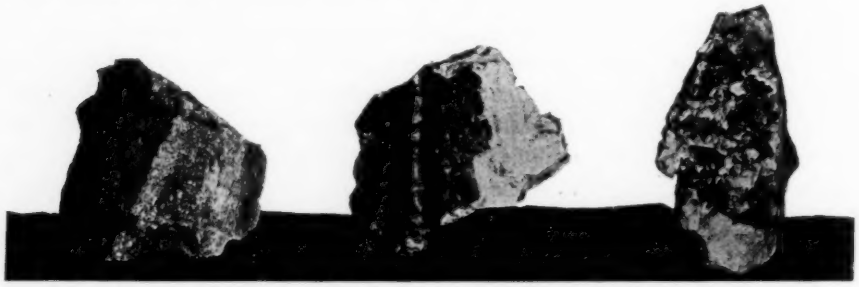
The bonding properties of silica cement with silica brick are very slight even at high temperatures. If the cement is buttered between two silica 9-inch brick and then subjected to a temperature of 1450°C in a test furnace for 72 hours, the bricks will be found to be fairly well bonded together while hot, but when they have been allowed to cool the bond will be very slight. If, however, these bricks are heated under a pressure of fifteen pounds per square inch in the same manner, and then allowed to cool while still under this pressure, it will be found that the bricks are fairly well bonded together. The bonding qualities of silica cement are then very slight unless subjected to considerable pressure or unless the cement is of a sufficiently low refractory quality to cause it to soften or vitrify at the operating temperatures. In the latter case this softening of

the cement causes it to attack the brick and consequently a hard bond is formed, which will not allow the bricks to be separated without breaking them. As has, however been previously stated, the bonding property should not be obtained at the expense of the refractoriness, because it seriously impairs the life of the brickwork. The result of silica cement fusion is shown in Fig. 1 of pieces of bricks taken after actual service in a furnace.

No. 1—Shows the silica cement fused in the joint, but not running out of it.

No. 2—Undoubtedly was subjected to a slightly higher temperature and shows the silica cement fused and run out of the joint, causing a slight attack on the brick.

No. 3—Subjected to a still higher temperature shows the fused mass of brick and cement. This plainly illustrates the result of the attack and impairing of the life of the brick itself.



I II III

Effect of Silica Cement Fusion on Silica Brick.

I.—Shows silica cement fused in the joints but not running out.
II.—Shows silica cement fused and run out of the joints.
III.—Shows fused mass of brick and cement.

If it is necessary, however, it has been found that the bonding qualities can be greatly improved, without reducing the refractoriness, merely by the addition of a certain amount of molasses to the water when mixing. Other organic substances might be just as suitable, but molasses is comparatively cheap and gives very satisfactory results. It is not absorbed as readily by the brick as water, and consequently this may cause the cement to fill the pores and then produce a better bond. The burning out of the molasses may also leave carbonaceous matter which tends to bond the cement and brick. Tests have proved that a high refractory cement mixed with part molasses and part water will give a hard bond when heated at 1450°C for 72 hours without being subjected to pressure. In fact the bricks had to be cut apart with a chisel and hammer. They broke

through the cement, leaving part of the cement bonded to each brick. Even at a temperature between 900° and 1000°C a fair bond was produced, which required a considerable pull to break, and as before the break was through the cement. Several tests were made using cements from different manufacturers so that there might be no chance for error, and in each case at temperatures ranging between 1000° and 1450°C the difference in the bond produced with and without the molasses, was unquestionably very marked. Fusion point determinations made on a cement with molasses added showed the same refractoriness as without. It is also a curious fact that silica cement or ground silica bats, if mixed with molasses and applied to a hot silica brick surface, will adhere firmly to the bricks, and consequently it can be used to fill any cracks or crevasses, which may have developed in the brickwork after service.

SEMET-SOLVAY COMPANY
SYRACUSE, NEW YORK

THE DISINTEGRATION OF REFRACTORY BRICK BY CARBON MONOXIDE[1]

By B. M. O'Harra,[2] and W. J. Darby[3]

In experimental work carried on at East St. Louis, Ill., in 1916 and 1917, with a furnace of commercial size for the electrothermic dry distillation of zinc ores,[4] a difficulty that developed was the destruction of the fire-brick lining in certain parts of the large condenser. The condenser was satisfactory in other ways, yielding a large proportion of the zinc as liquid metal, with no blue powder; but in order to obtain a proper length of service from the condenser it became necessary to find and overcome the cause of the disintegration of the lining.

The fire-brick lining of the large retorts in which the charge was distilled showed no disintegration similar to that of the condenser, and in fact required no repairs during the time the plant was in operation, although they were subjected to temperatures of from 1200° to 1300°C, with sudden cooling about once in eight hours when transferred to a new charge. Neither was the condenser lining destroyed in those portions of the condenser which were at comparatively high temperatures, marked disintegration taking place only at temperatures between about 450° and 550°C.

The fire brick used in the condensers were of good grade but showed numerous "iron spots." An examination of the disintegrated brick showed that these iron spots had been filled with fine sooty carbon, and that rupture was due to the increase of volume caused by this deposition of carbon. The carbon results from the reaction $2CO = CO_2 + C$, which takes place actively at temperatures between 450° and 600°C in the presence of catalysts such as metallic iron, which in the present instance would result from the reduction of the particles of iron oxide by carbon monoxide.[5]

This destruction of fire brick by carbon deposition at temperatures

[1] Published by permission of the Director of the U. S. Bureau of Mines.

[2] Associate Metallurgist, U. S. Bureau of Mines.

[3] Graduate Fellow in Metallurgy, Missouri School of Mines and Metallurgy.

[4] C. H. Fulton, "Electric-resistance Furnace of Large Capacity for Zinc Ores," *Amer. Inst. Min. & Met. Eng., Trans.*, **64,** 188–226 (1920).

[5] For data on the reaction $2CO = CO_2 + C$, see:

O. Boudouard, "Sur la decomposition de l'oxyde de carbone en presence de l'oxyde de fer," *Compt. rend.*, **128,** 98–101 (1899); "Sur la decomposition de l'oxyde de carbone en presence des oxydes metalliques," *ibid.*, 822–24; "Sur la decomposition de l'acide carbonique en presence du charbon," *ibid.*, 824–25; "Sur la decomposition de l'oxyde de carbone en presence des oxydes metalliques," *ibid.*, 1522–23; "Sur la decomposition de l'acide carbonique en presence du charbon," *ibid.*, 1524–25; "Recherches sur les equilibres chimiques," *Annales de chimie et de physique*, **24,** 5–85 (1901).

R. Schenck and F. Zimmerman, "Über die Spaltung des Kohlenoxyds und das Hochofengleichgewicht," *Ber. Deut. Chem. Gesell.*, **36,** 1231–51 (1903).

R. Schenck and W. Heller, "Uber die gegenseitigen Bezeihungen der verschiedenen Kohlenstoffmodificationen," *Ber. Deut. Chem. Gesell.*, **38,** 2139–43 (1905).

T. F. E. Rhead and R. V. Wheeler, "The Effect of Temperature on the Equilibrium

between 450° and 600°C is a well-known, though not common occurrence in iron blast furnaces, and has been discussed by several writers.[1] Firmstone has also described a case in which carbon deposited around angle irons laid in the bed joints of the upper part of a blast furnace lining to such an extent that the lining rings and hoppers were raised as much as nine or ten inches.

Disintegration caused by carbon deposition has also been noted in the lining of producer gas flues, in coke oven refractories, and in the checkerwork of regenerative producer-gas fired furnaces, and is guarded against by the use of fire brick low in iron for these purposes.

Bernhard Osann described some experiments in 1907[2] in which pieces of refractory material were placed in a porcelain boat in a combustion tube and subjected at a temperature between 450° and 500°C to a current of carbon monoxide passing at the rate of 1.74 liters per minute. In four days the fire brick showed signs of disintegration and in seventeen days fell completely to pieces. Deposition of carbon around particles of iron in the brick was given by Osann as the cause of disintegration.

Carbon deposition around iron spots in the refractory lining of a zinc condenser would naturally be more vigorous than in blast furnaces or in the checkerwork of regenerative furnaces, as the gas in a zinc condenser is, aside from the zinc vapor, nearly pure carbon monoxide, whereas blast furnace gas and producer gas contain much inert nitrogen and considerable carbon dioxide. The small condensers used in the usual retort process of smelting zinc ores are subjected to much rough handling and have an average life of only about ten days, so that if a fairly good quality of fire clay is used in them the effect of carbon deposition is not very noticeable. The large condensers necessary in smelting zinc ores by an electrothermic

$2CO = CO_2 + C$," *Jour. Chem. Soc.*, **97,** 2178–89 (1910); "The Effect of Temperature and Pressure on the Equilibrium $2CO = CO_2 + C$," *ibid.*, **99,** 1140–53 (1911); "The Rate of Reduction of Carbon Dioxide by Carbon," *ibid.*, **101,** 831–45 (1912).

See also G. N. Lewis and Merle Randall, "The Free Energy of Some Carbon Compounds," *Jour. Am. Chem. Soc.*, **37,** 458–70 (1915).

[1] John Pattinson, "On Carbon and Other Deposits from the Gases of Blast Furnaces in Cleveland," *Iron and Steel Inst. Jour.*, **1,** 85 (1876).

Limbor, *Wochenschrift des Ver. deut. Ingen.*, 259 (1878); *Bull. de l'Industrie Minerale*, 2d. ser., tome X, 483 (1881).

F. W. Lurman, *Stahl u. Eisen*, **18,** 168 (1898).

Bernhard Osann, "Einwirkung zerstörender Einflüsse auf feuerfestes Mauerwerk im Hüttenbetreibe," *Stahl u. Eisen*, **23,** 823–29 (1903).

Frank Firmstone, "An Example of the Alteration of Fire-brick by Furnace Gases," *Amer. Inst. Min. Eng. Trans.*, **34,** 427–31 (1904).

Raymond M. Howe, "Blast Furnace Refractories," Appendix, *Amer. Inst. Min. & Met. Eng., Trans.*, **62,** 761–67 (1920).

[2] Bernhard Osann, "Der experimentelle Nachweis der Schachtzerstörung in Hochofen durch ausgeschiedenen Kohlenstoff," *Stahl u. Eisen*, **27,** 1626–8 (1907).

process must, however, have a comparatively long life, and it is essential that a refractory material for lining them be found that will withstand the action of carbon monoxide.

From the preceding discussion it will be evident that an iron-free refractory material would probably be suitable. To demonstrate this and to test the effect of carbon monoxide on various refractory materials a series of tests was carried out at the Mississippi Valley Station of the Bureau of Mines, in coöperation with the Missouri School of Mines and Metallurgy. These tests are described in the following pages.

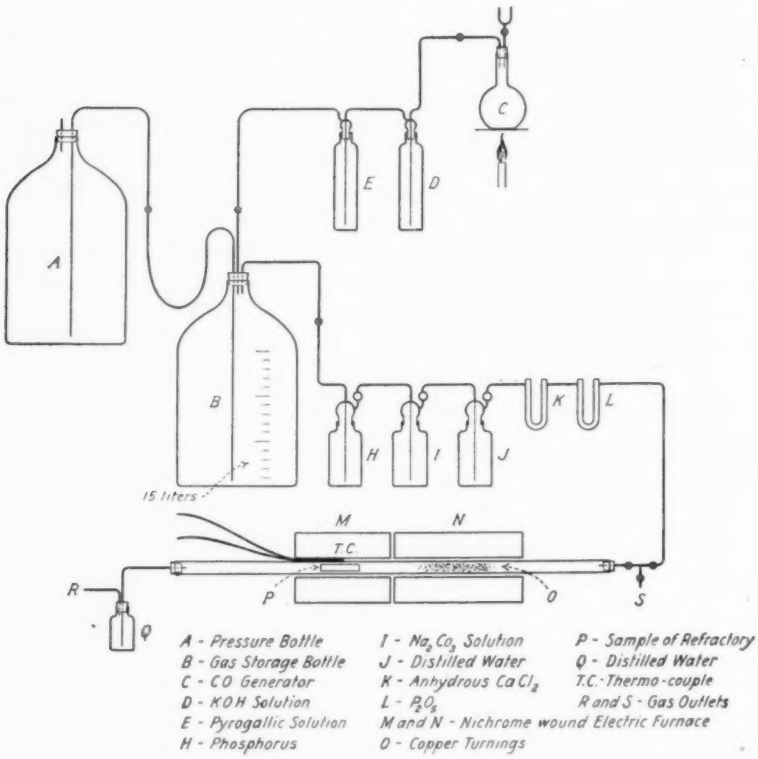


FIG 1.

Apparatus Used

Carbon monoxide for use in the tests was prepared by warming concentrated sulphuric acid with formic acid in a 500 cc. flask, and was freed of carbon dioxide and oxygen by bubbling through concentrated potassium hydroxide solution and potassium pyrogallate solution. The purified carbon monoxide was collected in a large gas storage bottle. The pressure in this storage bottle was regulated by raising or lowering a pressure

bottle of the same size filled with water, which was placed on a small elevator and connected to the storage bottle by means of a flexible siphon. Before the gas was passed over the refractory material it was further purified by being passed over stick phosphorus and through washing bottles containing, respectively, sodium carbonate solution and distilled water, and was then thoroughly dried by passing through U-tubes containing anhydrous calcium chloride and phosphorus pentoxide, respectively. Finally, the last of the oxygen was removed by passing over hot copper turnings and the carbon monoxide was conducted into the combustion tube containing the sample of refractory material, as described below.

The sample of refractory material upon which the effect of the carbon monoxide was to be determined was placed in a pyrex glass combustion tube 20 mm. in diameter, and heated and kept at a constant temperature in a horizontal ni-chrome wound electric resistance furnace. The temperature of the sample was read by means of a thermocouple, the junction of which was placed outside, but touching the wall, of the combustion tube.

A wash bottle containing distilled water was attached to the exit end of the combustion tube to prevent air being drawn back into the apparatus. Samples of gas could be taken at either end of the combustion tube, before or after passing over the sample of refractory.

The rate at which the carbon monoxide was passed through the combustion tube containing the sample varied from 0.1 to 1.0 liter per hour. This was sufficient to keep up a fresh supply of pure carbon monoxide but allowed the carbon dioxide to build up sufficiently so that an analysis of the exit gas would indicate roughly, by the per cent of carbon dioxide found, the rate at which carbon deposition was taking place in the sample.

Tests were made upon four samples of fire-clay brick, one of which was tested at three different temperatures, and upon one sample each of silica brick, magnesite brick, carborundum brick and chrome brick.

Tests on Fire Brick

The first fire brick tested, Fire Brick A, was one which was selected because it contained many large and very noticeable spots, or splotches, of iron oxide. An analysis gave:

Fe_2O_3	3.72%
SiO_2	57.12%
Al_2O_3	41.63%
CaO	0.77%

Figure 2 is a photograph of one end of this brick and shows the iron spots plainly.

Tests were run on Fire Brick A at 550°, 650° and 750°C.

Test No. 1.—In test No. 1, a piece of the brick was subjected to the action of a current of carbon monoxide for 29 hours at a temperature of

550°C. The carbon monoxide gas was passed at an average rate of about 1 liter per hour. Samples of the gas entering the combustion tube contained no carbon dioxide, while four samples taken at different times of the gas after passing over the sample of fire brick contained, respectively 4.4, 3.4, 3.4, and 1.4% carbon dioxide. At the end of 29 hours deposits of sooty carbon were found to have formed at the iron spots in the test piece, and near the larger spots the brick had swelled out and large cracks radiated from the deposits of carbon. *A* and *C*, Fig. 3, are two views of the test piece showing plainly the swelling and cracking caused by the deposition of carbon. *B* is a piece of the original brick, before being exposed to the carbon monoxide.

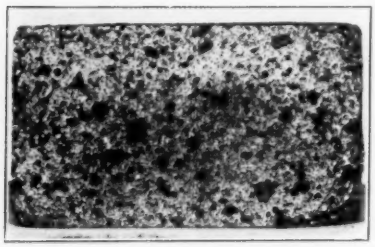


FIG. 2.—Photograph of one end of Fire Brick *A*, showing splotches of iron oxide.

During the test the brick was subjected to no sudden changes of temperature, nor to any other disintegrating influences other than the carbon monoxide. This fact, together with the fact that the cracks radiated

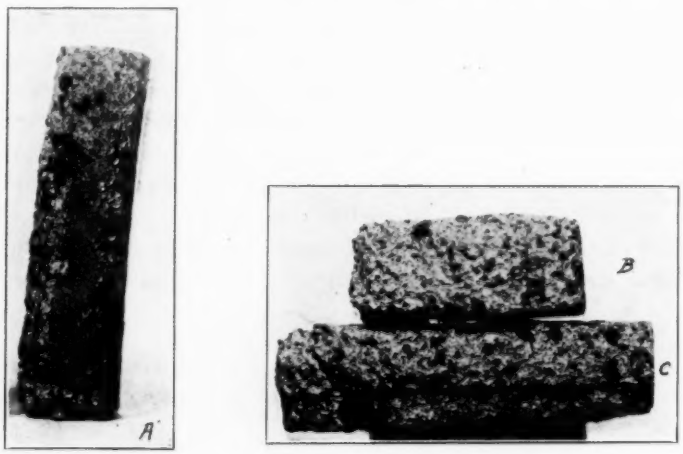


FIG. 3.—*A* and *C*: Two views of a test piece of Fire Brick *A*, after exposure for 29 hours to carbon monoxide at a temperature of 550°C, showing cracks radiating from the larger deposits of carbon. *B*: piece of brick before exposure to carbon monoxide.

from the carbon deposits formed at iron spots in the brick, and that marked swelling took place around these carbon deposits, indicates conclusively that carbon deposited by the reaction $2CO = CO_2 + C$ at iron spots was the cause of the cracking.

Test No. 2.—Test No. 2 was also on a sample of Fire Brick A, and was similar to test No. 1, except that the temperature was held at 650°C. Two samples of gas taken at the exit from the combustion tube contained, respectively, 4.8% and 4.4% carbon dioxide. In this experiment the carbon monoxide was passed at the rate of only 0.2 to 0.3 liter per hour, so the actual amount of CO_2 formed was not as great as in test No. 1. Test No. 2 was continued for 44 hours. At the end of that time the test piece had an appearance similar to that of the one from test No. 1, but the carbon deposit was not so voluminous nor the cracks as large.

Test No. 3.—In test No. 3, also on a sample of Fire Brick A, the temperature was held at 750°C. The velocity of the current of carbon monoxide was about the same as in test No. 2. A sample of the exit gas taken soon after the beginning of the test contained 4.0% carbon dioxide, but samples taken at various later times contained only from 1.2% to 2.0%. The time of this test was 51 hours. Upon examination of the test piece at the end of that time it was found that some carbon had deposited at the iron spots, but the amount was much smaller than in the tests at 550° and 650°C, and no visible cracks or sign of weakening had yet developed.

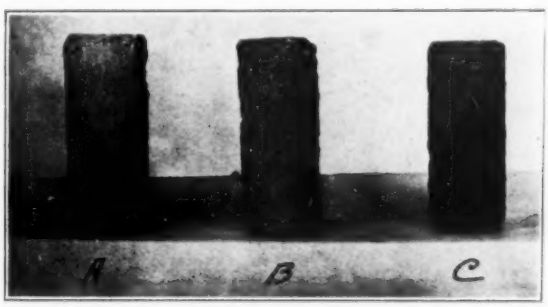


FIG. 4.—Test pieces from Fire Brick *B*: *A*, after baking at 650°C; *B*, after burning at 1300°C; *C*, after exposure for 113 hours to carbon monoxide at a temperature of 550°C.

Tests Nos. 1, 2, and 3, illustrate the fact that the disintegrating effect of carbon monoxide becomes less as the temperature rises above 550°C.

Test No. 4.—Fire Brick B, used in test No. 4, was a small test brick made up in the laboratory from a mixture of raw fire clay and grog supplied ready for use by a fire brick manufacturing company in response to a request for a fire clay of low iron content that would be resistant to the effect of carbon monoxide. The analysis of the mixture was:

Fe_2O_3	2.47%
SiO_2	47.04%
Al_2O_3	34.62%
CaO	nil

The test bricks were molded in a small cylindrical briquet mold, dried at 105°C for about 20 hours, baked at 650°C for 20 hours, and finally burned at 1300°C for thirty minutes. None of the brick cracked during

drying or burning. The finished brick contained some specks of iron oxide, but they were of very small size and less numerous than in either Fire Brick A or C.

In this test the temperature was maintained at 550°C. The carbon monoxide was passed through the combustion tube at an average rate of about 0.3 liter per hour. Analyses of the exit gas, after passing over the test piece, showed it to contain from 0.6% to 1.4% carbon dioxide, much less than in any of the preceding tests. This test was continued for 113 hours, at the end of which time the brick was darkened by a superficial coating of carbon but contained no marked carbon spots and showed no sign of disintegration. In Fig. 4 are shown three test pieces of Fire Brick B; *A*, after baking at 650°C; *B*, after burning at 1300°C; and *C*, after being subjected to the action of carbon monoxide at 550°C for 113 hours.

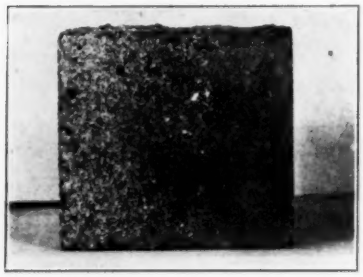


FIG. 5.—Photograph of one end of Fire Brick *C*.

Test No. 5.—The brick used for test No. 5, Fire Brick C, was one selected at random from a pile of a standard make of fire brick. The iron spots in it were not as large or noticeable as in Fire Brick A, but were more thickly distributed throughout the brick. Figure 5 is a photograph of an end of this brick. Following is its analysis:

Fe_2O_3	3.72%
SiO_2	64.34%
Al_2O_3	25.83%
CaO	nil

The rate of flow of the carbon monoxide in this test was 0.2 liter per hour, and the temperature 550°C. At the end of 24 hours the test piece had completely fallen to pieces; a large part of it would have passed through a 10-mesh screen. The disintegrated material contained 1.045% carbon. Fig. 6 is a photograph of *A*, a test piece of the brick before exposure to carbon monoxide; and *B*, the disintegrated test piece from test No. 5. No analysis of the exit gas was obtained during this test. A second test at the same temperature on another sample of this same brick was started, and the test piece more closely watched during the first few hours. A sample of the exit gas in this test contained 5.0% carbon dioxide. At the end of the first hour the brick had started to swell and at the end of 12 hours incipient cracking could be seen. The combustion tube cracked, bringing the test to an end, before the brick had completely broken down.

Test No. 6.—Fire Brick D, used in test No. 6, was a small test brick made up in the laboratory, in the same way as Fire Brick B, from a mixture

of equal parts of raw fire clay and grog. These were supplied, like the mixture used for Fire Brick B, in response to a request for a low-iron fire clay to resist the action of carbon monoxide. The analysis of the mixture of clay and grog was:

Fe_2O_3	2.02%
SiO_2	59.48%
Al_2O_3	29.70%
CaO	nil

The temperature of the experiment was 550°C, and the carbon monoxide was passed through the combustion tube at an average rate of 0.23 liter per hour. Samples of the exit gas taken at various times during the experiment contained, respectively, 1.6, 0.8, 0.7, 1.4, 0.2, and 0.5% carbon dioxide. The test was continued for 120 hours. At the end of that time the test piece was darkened by a superficial coating of carbon but no sign of disintegration could be observed. The appearance of the test piece before and after being subjected to the action of the carbon monoxide was similar to that of the test piece of Fire Brick B (Fig. 4).

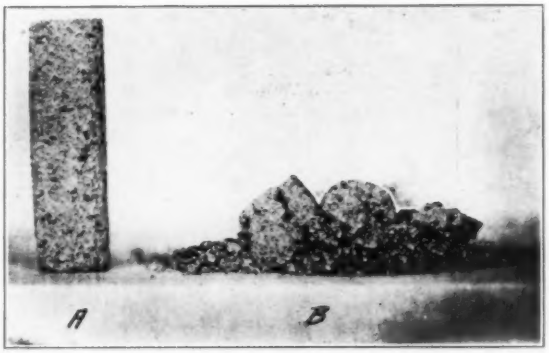


FIG. 6.—*A*, test piece of Fire Brick *C* before exposure to carbon monoxide. *B*, test piece of Fire Brick *C* after exposure for 24 hours to carbon monoxide at a temperature of 550°C.

Summary of Results of Tests on Fire Brick.—Tests 1, 2, 3, and 5, show in a conclusive way the manner in which ordinary fire brick containing many particles of iron oxide are broken up by the increase in volume produced by the deposition of carbon at "iron spots," due to the catalysis by iron of the reaction $2CO = CO_2 + C$. Tests 1, 2, and 3 illustrate the fact that the detrimental action of carbon monoxide is not great at moderately high temperatures, but increases rapidly as the temperature approaches 550°C.

Tests 4 and 6 prove that fire brick of low iron content will withstand the action of carbon dioxide for a much longer time than fire brick of high iron content; in fact the difference in the behavior of Brick A and C, containing 3.72% Fe_2O_3, and Brick B and D, containing 2.47 and 2.02%, respectively, is surprisingly great. Brick B and D would doubtless in time disintegrate under the influence of carbon monoxide at tem-

peratures favorable for its decomposition into carbon and carbon dioxide, but the tests leave no doubt but that fire brick sufficiently low in iron would withstand its action for a long period of time.

Test on Silica Brick

Test No. 7.—The test piece used for test No. 7 was from a silica brick containing 0.83% Fe_2O_3 and 94.0% SiO_2.

The temperature was 550°C and the rate of flow of the carbon monoxide was 0.16 liter per hour. A sample of the exit gas from the combustion

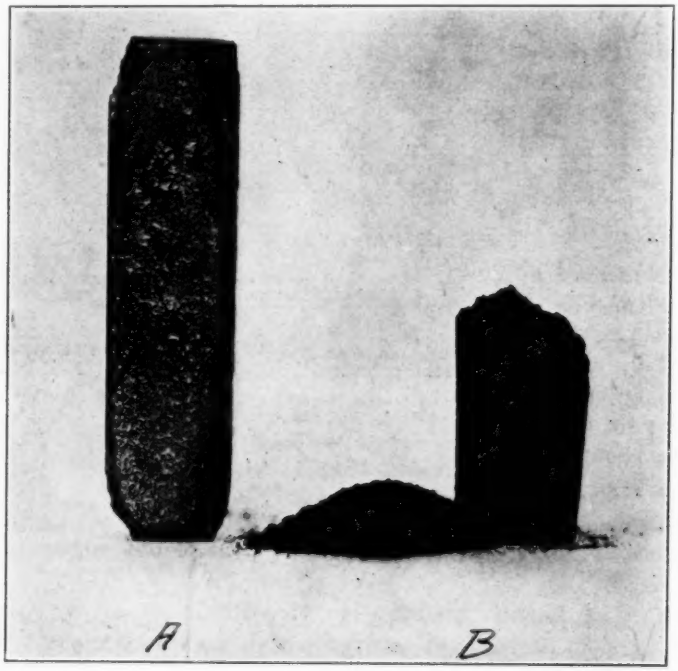


FIG. 7.—*A*, test piece from magnesite brick before exposure to carbon monoxide. *B*, test piece of magnesite brick after exposure for 53 hours to carbon monoxide at a temperature of 550°C.

tube contained 0.6% carbon dioxide. The test was continued for 114 hours. No coating of carbon was formed on the test piece, which was totally unaffected by the treatment.

Test on Magnesite Brick

Test No. 8.—Temperature, 550°C. Rate of flow of the carbon monoxide, 0.15 liter per hour. The sample used for this test was from a magnesite brick having the following analysis:

Fe_2O_3	5.02%
SiO_2	6.43%
MgO	84.7 %

Two samples of the exit gas contained, respectively, 7.4% and 7.7% of carbon dioxide. After 48 hours the test piece had swelled and cracked and at the end of 53 hours about half of it had fallen completely to a powder. The remainder was friable and could be easily pulverized between the fingers. Both the disintegrated powder and what remained of the original test piece had been changed to a dull black color by the carbon deposited. The disintegrated portion contained 1.056% carbon. Figure 7 is a photograph of *A*, a sample of the original brick, and *B*, the disintegrated test piece.

Test on Carborundum Brick

Test No. 9.—Temperature 550°C. Rate of flow of the carbon monoxide, 0.17 liter per hour. The test piece was a piece of carborundum brick selected at random from a lot which had been purchased for other purposes. It was not analysed.

Two samples of the exit gas during the experiment contained, respectively, 1.0% and 0.4% carbon dioxide. The test was continued for 117 hours. The brick was not affected by the treatment. There may have been a slight coating of carbon which would not have been easily noticeable because of the black color of the original brick, but there was no deposition of carbon of any importance.

Test on Chrome Brick

Test No. 10.—Temperature, 550°C. Rate of flow of the carbon monoxide, 0.28 liter per hour. The test piece was a piece of chrome brick having the following analysis:

FeO	13.9%
SiO_2	7.9%
Al_2O_3	13.5%
Cr_2O_3	40.0%
MgO	21.1%

Samples of the exit gas contained 1.0% and 1.6% carbon dioxide, respectively. The duration of the test was 121 hours. Sufficient carbon deposited on the brick to color it black, but there was no sign of weakening or disintegration of the brick. This is somewhat surprising, in view of the high iron content. All but a little of this iron is, however, required to form chromite, $FeO.Cr_2O_3$, with the chromic oxide. There is probably very little iron present in the form of free oxides reducible to Fe at 550°C, and the $FeO.Cr_2O_3$ evidently does not act as a catalyzer of the reaction $2CO = CO_2 + C$.

Summary and Conclusions

The series of experiments which have been described illustrate forcibly the disintegration of refractories that can be caused by the increase in volume brought about by the deposition of carbon; this deposition of carbon resulting from the decomposition of carbon monoxide according to the reaction $2CO = CO_2 + C$, at temperatures of about 550°C. This reaction does not take place to an appreciable extent in the absence of catalyzers, but metallic iron acts as a catalyzer and in its presence carbon deposits readily. Particles of iron oxide in refractory brick are reduced at low temperatures by carbon monoxide to metallic iron and carbon then deposits around the particles of iron, exerting sufficient expansive force to disrupt the brick. As would be expected the deposition of carbon is less and the disintegrating effect is less as the percentage of iron present as reducible iron oxide decreases. In the absence of iron, or if the iron is present as a compound which is not reduced by carbon monoxide at low temperatures, there is no deposition of carbon and the strength of the refractory is not affected. Carbon deposition and the disintegration caused by it decrease at temperatures above 550°C and are not important above about 750 or 800°C.

Ordinary fire brick and magnesite brick are rapidly disintegrated in an atmosphere of carbon monoxide at temperatures favorable for its decomposition into carbon and carbon dioxide, but iron-free fire brick, silica brick, carborundum brick, or chrome brick (low in free iron oxide) are not affected.

For use as a lining for large zinc condensers, such as are required for the electrothermic distillation of zinc ores, either iron-free fire brick or silica brick would be satisfactory, silica brick being the better of the two. Chrome brick or carborundum brick would also be satisfactory but would be more expensive and would be no better than silica brick.

THE EFFECT OF VARIATION IN FIRING ON THE PHYSICAL PROPERTIES OF VITREOUS CHINA BODIES[1]

By H. H. Sortwell

ABSTRACT

The porosity, transverse strength, compressive strength and impact strength of ten commercial china bodies were determined on sets of specimens fired in three positions in a kiln in each of ten potteries. The results showed that while there was considerable difference in the maximum strength of the bodies, nearly all of them developed high strength when fired most advantageously. The maximum strength existed over a narrower range in heat treatment than that of complete vitrification. Underfiring and overfiring of this type of body caused serious loss in strength.

Specimens of eleven bodies fired at cones 6, 8, 10, 12 and 14 in a laboratory kiln showed about the same differences in maximum strength as specimens of the same bodies fired in the pottery kilns. In one body only was as high strength developed in the small kiln as in the factory. In most instances the highest strength developed was coincident with complete vitrification and in all the bodies it occurred near or prior to cone 12. There was considerable difference in the range in temperature over which the different bodies were vitrified and were of high strength. While two of the bodies were excellent in this respect, the remainder were vitrified and of high strength through only a narrow temperature range.

Introduction

All manufacturers of ceramic products meet difficulties in maintaining a satisfactory degree of uniformity in their product. Especially is this true in the manufacture of vitreous wares, including hotel china, which should be uniformly vitrified so as not to discolor badly when the body is exposed by the loss of portions of the glazed surface by chipping, but which at the same time should not be fired to the point where the structure becomes glassy enough to be brittle.

Numerous factors cause variations in the ware, including the lack of uniformity in composition and fineness of the raw materials, the details of body preparation, the methods and workmanship employed in forming the ware, and the firing. Without doubt, the firing is the most variable factor in the manufacturing processes. Uniformity of heat treatment throughout commercial kilns is difficult to attain, and the lack of uniformity affects the ware in greater degree than the other causes of variation.

In discussing specifications for hotel china, the question of requirements for uniformity of ware had to be considered. At the meeting of the Research Committee of the United States Potters Association at the Bureau of Standards in April, 1922, this subject was discussed and it was decided that an investigation of the uniformity of the bisque obtained in vitreous china kilns would be of value to the potters and of general interest to the ceramic industry as a whole.

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

While the volume of work reported on vitreous body compositions is large and does not need reviewing in detail here, only one investigation of commercial bodies of this type has been published. In the Bureau of Standards laboratory Wright and Sewell[1] studied several bodies in use at that time on a laboratory scale, confining their work mainly to the physical properties of the body "clay" and the porosity-temperature relations during firing.

All of the heat treatment measurements in this work were made by pyrometric cones in order to conform to the factory practise in the potteries which coöperated in the work.

Scope of the Investigation

Through C. E. Jackson, chairman of the American Vitrified China Manufacturers Association, it was arranged for a member of the Bureau staff to visit the potteries of the Association for the purpose of making specimens for the determination of porosity, transverse strength, compressive strength and impact strength. It was desired that the pieces from all the potteries be made by the same man to eliminate as far as possible the personal factor in the preparation of the specimens and to insure uniformity in the size of the pieces.

Enough specimens were made so that three sets could be fired in a kiln in what were considered the hottest, average, and coolest parts, one complete set in each position. In most cases the specimens were placed in the first, second and third rings. Each set was put in one sagger with cones and after firing, the specimens, together with the cones, were forwarded to the Bureau laboratory for testing.

In addition to the study of the uniformity obtained in the commercial kilns, an investigation of the variation in the physical properties of the bodies over a much wider range in temperature was made. Each of the potteries interested shipped one hundred pounds of plastic body to the laboratory, where it was made into similar pieces and fired at cones 6, 8, 10, 12 and 14 in a small natural draft gas-fired kiln. The burns were of about thirty hours duration. The heat treatment as shown by cones in the saggers and on the bags varied by less than half a cone in different parts of the kiln in each burn.

Testing Procedure

For the determination of the transverse strength, bars $6 \times 1 \times 1$ inches were pressed from the plastic body in brass molds by the usual method. Twelve bars were made for each position in the kiln and the results represent the average of at least ten. The fired pieces were broken

[1] J. W. Wright and S. I. Sewell, *Jour. Amer. Ceram. Soc.*, **2** [4], 282 (1919).

over a five-inch span in an Olsen transverse testing machine of 1,000 lbs. capacity. The broken specimens were measured for breadth and depth and the moduli of rupture computed.

The broken transverse specimens were used for the absorption, porosity and bulk specific gravity determinations. The dry weighed pieces were saturated with water by boiling under a vacuum for two hours and the calculations made by the usual formulas.

The compression test specimens were made by pressing the plastic body into cylinders two inches long and one inch in diameter in plaster molds. Six cylinders were fired in each set, and after firing were broken in a one hundred thousand pound capacity Riehle testing machine. The results represent the average of at least four specimens in each set.

For the impact tests discs five by one quarter inches were jiggered by experienced jiggermen in each pottery. The specimens were broken by striking them in the center with a six ounce hammer suspended on a wire arm making the total length of the suspension two feet. The discs were supported against three steel balls equidistantly spaced in a ring three and one quarter inches in diameter. The first blow was equivalent to 0.025 foot-pounds of energy and each blow was increased by this amount.

Results of Specimens Fired in Potteries

The results show the uniformity of the product in one kiln in each pottery and it is to be expected that unless very bad firing conditions obtained, the specimens in at least one part of each kiln would have approximately the maximum strength possible to be developed in the body by the most advantageous firing treatment.

Table I consists of the numerical results for the specimens fired in the potteries. Fig. 1 shows the apparent porosities in the different parts of each kiln. Bodies 2, 3, 5, 8 and 10 were uniformly vitrified. Body No. 7, which is no longer being used, was uniform in porosity, but in no part of the kiln was it sufficiently vitrified for this type of ware. The kilns containing Nos. 1, 4 and 6 were not sufficiently fired to produce uniform ware throughout. While the specimens in the first ring were properly vitri-

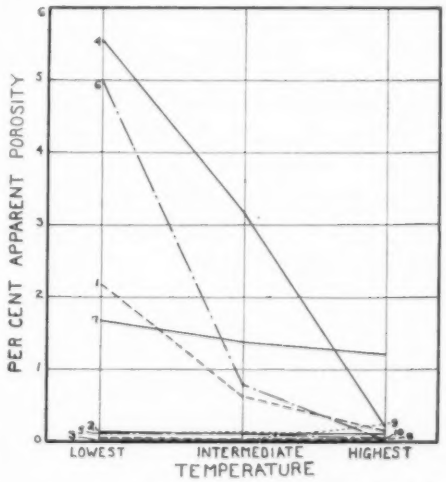


FIG. 1.—Porosity of specimens fired in potteries.

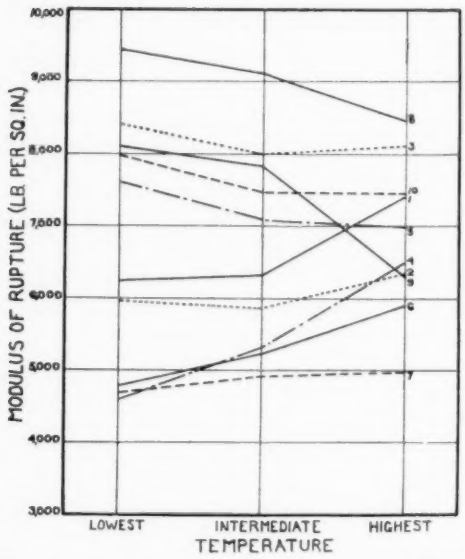


FIG. 2.—Transverse strength of specimens fired in potteries.

fied, those in the second and third rings were porous. The kiln containing body No. 9 was overfired. In this case the specimens in the second and third rings were properly vitrified, but in the first ring in which the heat treatment was more severe by one cone, the porosity had risen to 0.24 per cent.

The moduli of rupture are presented graphically in Fig. 2. The maximum transverse strength developed in each body varied from 4975 pounds per square inch for No. 7 to 9444 pounds per square inch for body No. 8. Most of the bodies tested had good strength when fired under the best conditions obtained in these kilns, six of the bodies showing a maximum modulus of rupture above 7,000 pounds per square inch, and two others between 6,000 and 7,000 pounds. The effect of the underfiring of Nos. 1, 4 and 6 on the transverse strength is clearly shown. The specimens which were not vitrified were considerably lower in strength than those which were properly matured. The average modulus of rupture of the overfired specimens of body No. 9 was almost 2,000 pounds per square inch lower than the maximum strength developed, showing the serious loss of strength which occurs when a commercial kiln of this body is slightly overfired.

Although the results of the compression tests were not as consistent as those for the tranverse strength, the average

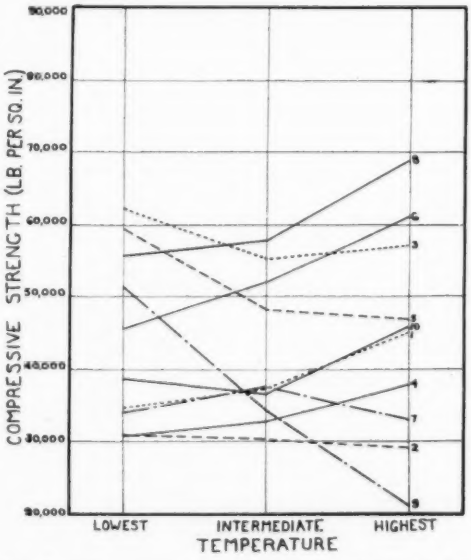


FIG. 3.—Compressive strength of specimens fired in potteries.

results given in Fig. 3 show the same general trend. The underfired specimens of Nos. 1, 4 and 6 were lower in compressive strength than the vitrified pieces, and the overfiring of No. 9 caused a reduction of 50 per cent in the ultimate compressive strength of that body.

The maximum compressive strength developed in these bodies varied from 31,000 pounds to 69,000 pounds per square inch. Body No. 8 which had the highest crossbreaking strength had the highest compression strength also and No. 7 which was not vitrified and had the lowest modulus of rupture failed at the lowest stress in compression. The variation in compressive strength shown by specimens of the same body uniformly vitrified would indicate, after allowing for experimental error, that the temperature range in which the maximum compressive strength is developed is not as wide as the vitrification range.

The results of the impact tests on the discs are shown in Fig. 4. The specimens of body No. 8 withstood much greater blows than those of the other bodies, which was due in part to the fact that the specimens were about 20% thicker than the others. While the impact strength is not a direct function of volume or thickness, differences of that magnitude would affect the results. In general, the impact test results are consistent with the strength of the bodies in the other tests, but the differences in the various parts of each kiln were not great. The higher fired specimens of each body, with the exception of No. 10, were of lower impact strength than those in the lighter fired portions of the kilns.

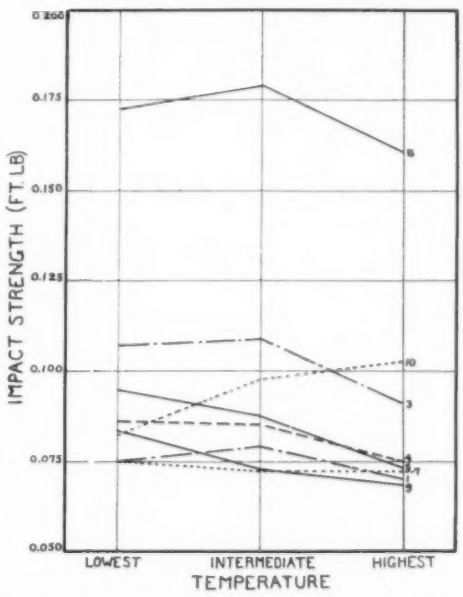


FIG. 4.—Impact strength of specimens fired in potteries.

Figures 5 to 14, inclusive, present graphically the assembled results for the specimens in each of the commercial kilns and show clearly the variations which occurred. Figs. 6, 7, 9, 11, 12 and 14 show bodies 2, 3, 5, 7, 8 and 10 respectively which were fired to uniform porosities throughout the kiln. Bodies 2, 3 and 7 were uniform both in porosity and in strength. While the specimens of No. 5 were equally vitrified, the drop in transverse, compressive and impact strengths shows that the firing of

the kiln was carried slightly past the point where the maximum strength throughout would have been obtained. Bodies 8 and 10, of uniform porosity, were increasing in compressive strength, while the moduli of rupture

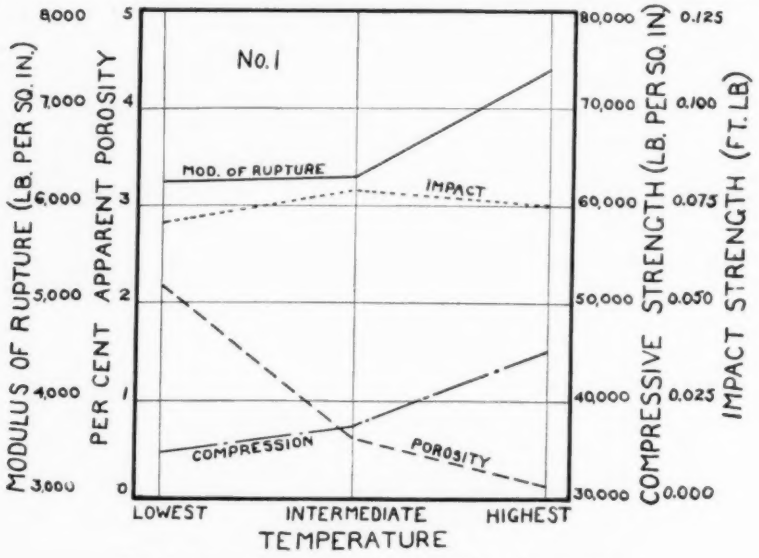


FIG. 5.—Results on body No. 1 fired in the pottery.

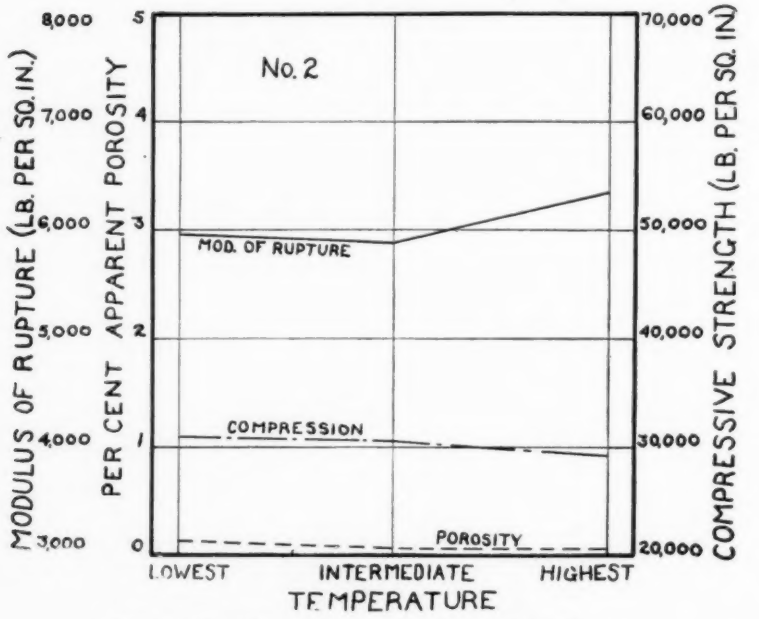


FIG. 6.—Results on body No. 2 fired in the pottery.

were decreasing, which might indicate that the maximum compressive and transverse strengths were reached at different conditions in the structure of the body.

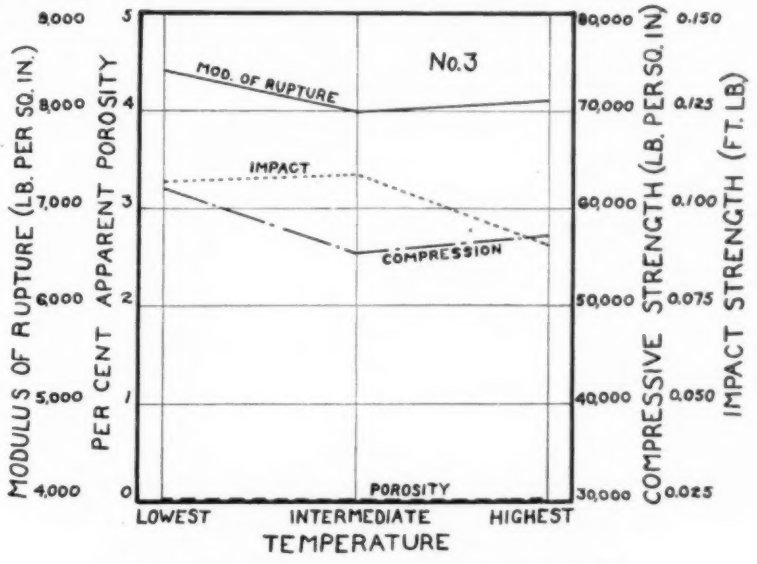


FIG. 7.—Results on body No. 3 fired in the pottery.

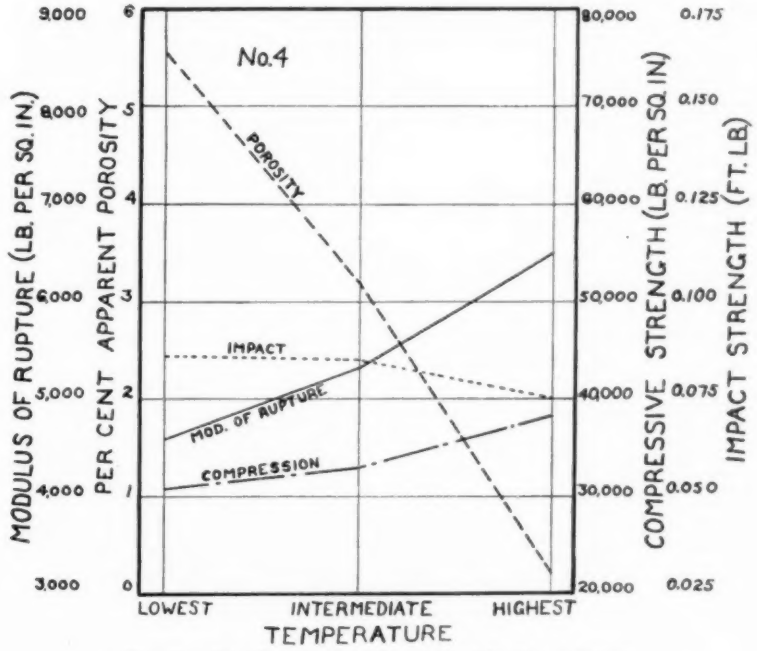


FIG. 8.—Results on body No. 4 fired in the pottery.

Figs. 5, 8, 10 and 13 show the effects of the underfiring of 1, 4 and 6 and the overfiring of 9 on the transverse, compressive and impact strength and their relation to the porosities of these bodies.

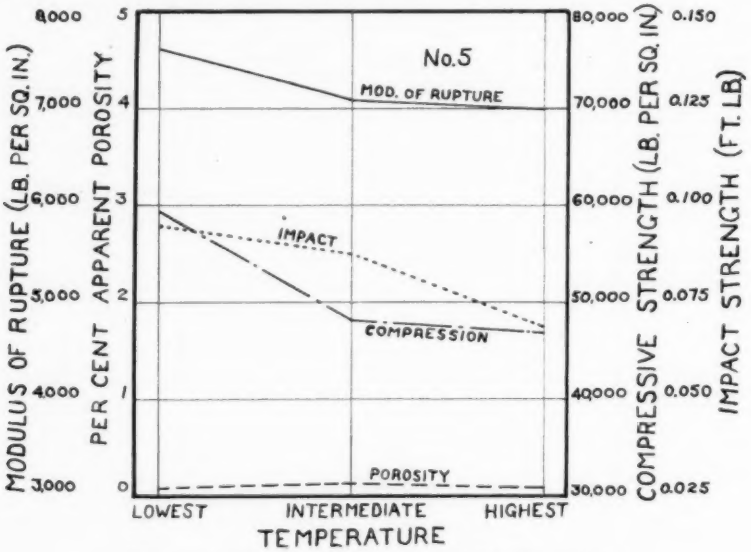


FIG. 9.—Results on body No. 5 fired in the pottery.

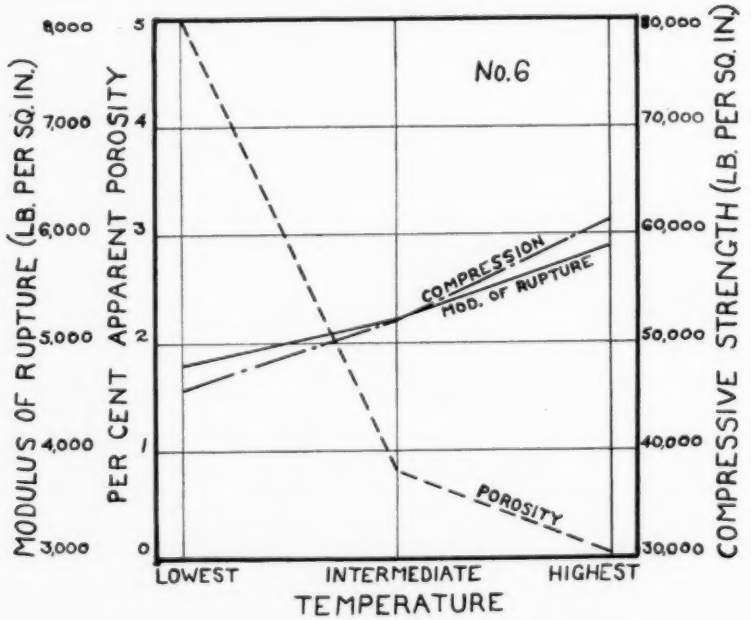


FIG. 10.—Results on body No. 6 fired in the pottery.

In general, the results of the work show that there are considerable differences in the physical properties of the body compositions in use, and furthermore that the kilns are often not finished at the point which would develop the maximum average strength throughout the kiln. In

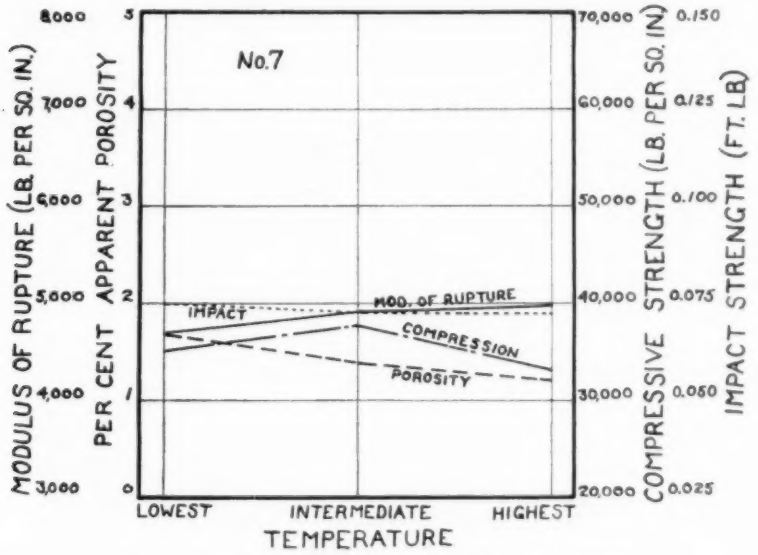


FIG. 11.—Results on body No. 7 fired in the pottery.

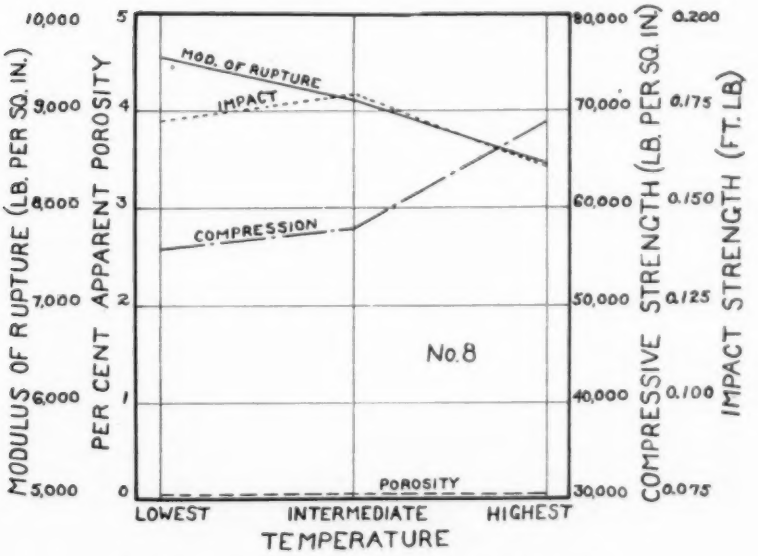


FIG. 12.—Results on body No. 8 fired in the pottery.

six of the ten kilns in which specimens were fired the pieces in the three positions in the kiln were evenly vitrified, which shows that the commercial kilns used can be fired to produce uniformly vitrified ware. That they are not always so finished is shown by the fact that three of the ten

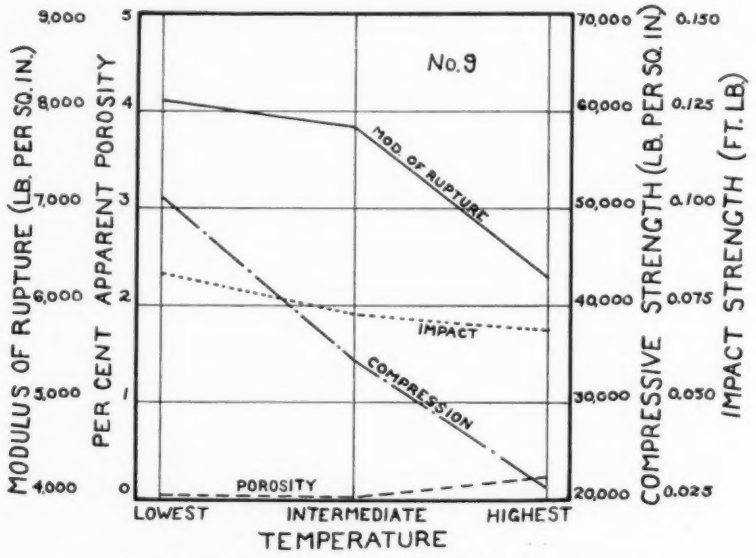


FIG. 13.—Results on body No. 9 fired in the pottery.

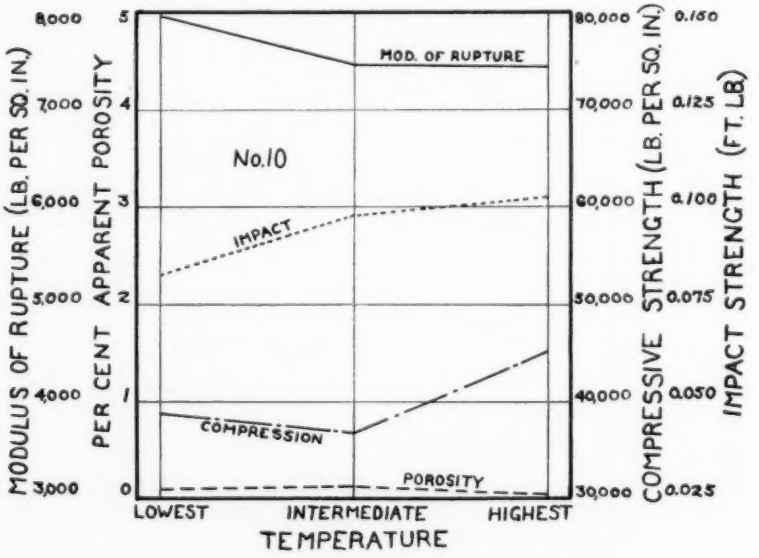


FIG. 14.—Results on body No. 10 fired in the pottery.

kilns were underfired and one overfired. The great importance of the proper firing of the bisque is apparent from a comparison of the strength of the underfired and overfired specimens with that of the same bodies when properly matured.

It would be advisable that tests of this kind be used more extensively in the industry in studying conditions in the kilns, body compositions and methods of body preparation. One of the most important requisites for hotel china, which is subjected to severe usage in restaurants, hotels, on railroads and steamships, is strength. Tests of this kind show the physical properties of a body itself exclusive of design with greater accuracy than tests of commercial shapes. The transverse strength, in

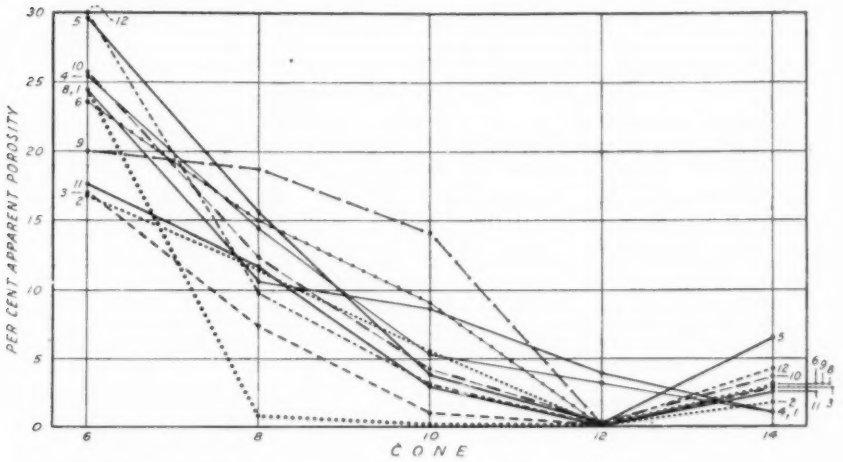


FIG. 15.—Per cent apparent porosity of bodies fired in the laboratory.

particular, can be determined easily, the results are significant and consistent, and the expense is not great. The use in the potteries of such tests in addition to the usual considerations of color and vitrification should result in more uniform bisque and stronger ware.

Results on Specimens Fired in the Laboratory

With the bodies fired at the Bureau of Standards two were included, Nos. 11 and 12, which were not in use at the time the potteries were visited, and one of the bodies fired in the pottery, No. 7, which was no longer being used, was omitted from this part of the investigation.

In studying the test results for the specimens fired in the laboratory it must be taken into consideration that the firing was done in a smaller kiln and at a more rapid rate of firing than the usual factory practice. This resulted in a slightly higher temperature being required to produce

a given condition in the body, and in only one case, No. 2, was as high a maximum strength obtained as in the larger pottery kiln. The numerical results are given in Table II.

The per cent apparent porosities of the eleven bodies fired to cones 6, 8, 10, 12 and 14 are shown graphically in Fig. 15. Considerable difference in the progress of vitrification of the specimens with increasing heat treatment is noted. The bodies may be divided into four general types in respect to firing behavior: namely, first, those vitrifying at from cone 8 to 10 and having a long vitrification range; second, those with porosity gradually reducing with increasing temperature and reaching a minimum in the neighborhood of cone 12; third, one which began vitrification later

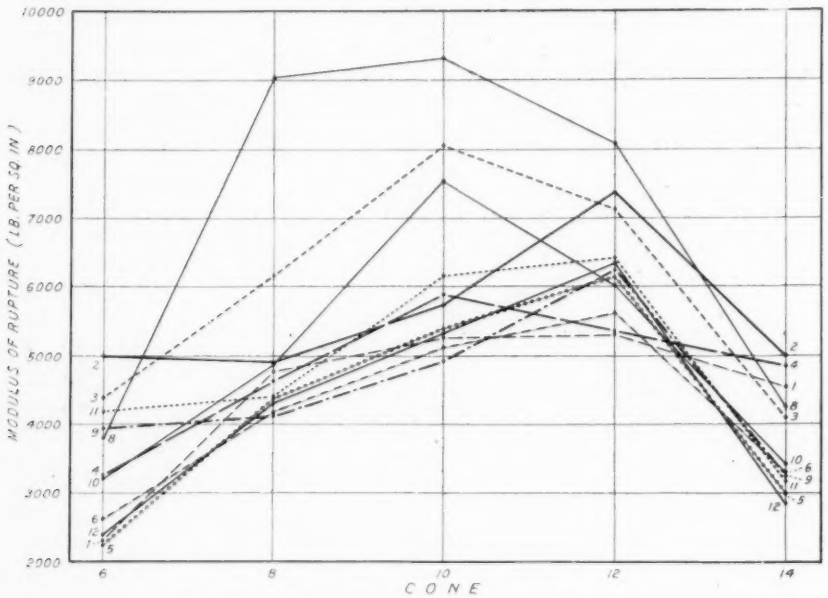


FIG. 16.—Transverse strength of specimens fired in laboratory.

than the preceding type and showed an abrupt decrease in porosity, vitrifying at the same temperature; fourth, bodies more refractory than those of the average composition and which, judging by the bulk specific gravities reached zero absorption between cones 12 and 14 in this kiln, over only a narrow range in temperature. Bodies 8 and 3 represent the first type. No. 8 was practically vitrified at cone 8 and had shown no signs of overfiring at cone 12. The second type includes six of the eleven bodies studied, 2, 5, 6, 10, 11 and 12. Body No. 9 was considerably behind the others in vitrification at cones 8 and 10, but decreased in porosity from 14.0% to 0.16% between cones 10 and 12. The fourth class, the

more refractory bodies, are represented by 1 and 4. The bulk specific gravities show that all of the bodies were overfired at cone 14.

The advantage to a potter of using a body with a vitrification behavior similar to that of No. 8 is obvious. Variations in heat treatment will have much less effect on the properties of a body with such a wide vitrification range, in producing ware of unsatisfactory quality than on those bodies which are properly vitrified during only a short range in temperature.

Fig. 16 shows the transverse strengths corresponding to the porosities just discussed. The development of the maximum transverse strength at cone 8 regardless of porosity which Schurecht[1] found to happen in

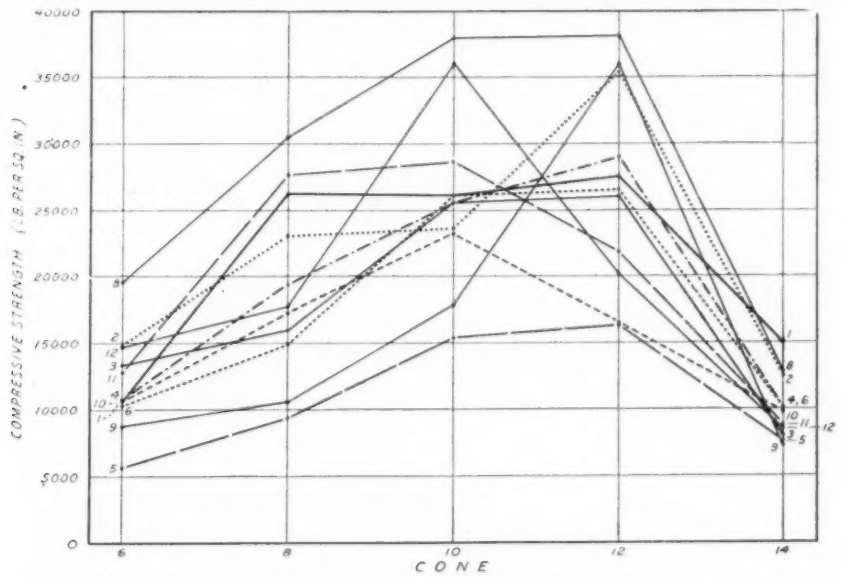


FIG. 17.—Compressive strength of specimens fired in laboratory.

stoneware clays did not occur in the compositions studied which were, of course, of an entirely different type. All of the eleven bodies studied reached their highest transverse strength near or prior to cone 12, and all suffered a great reduction in modulus of rupture between cones 12 and 14.

Seven of the eleven bodies attained their maximum transverse strength coincident with the minimum porosity obtained in these tests, Nos. 2, 5, 6, 9, 11 and 12 at cone 12, and No. 8 at cone 10. The greatest strength in No. 3 developed at cone 10 when the porosity was about 0.9 per cent, which is in the range of commercial vitrification for this type of bisque. Bodies 1, 4 and 10 developed their highest transverse strengths at porosities of 3.86, 5.33, and 4.03, respectively.

[1] H. G. Schurecht, *Jour. Amer. Ceram. Soc.*, **4** [5], 366 (1921).

The range in temperature of high transverse strength corresponded closely to the vitrification range, although some of the bodies did not show very great increases in modulus of rupture as vitrification was reached. Body No. 8 which had the widest vitrification range, also was high in transverse strength throughout the same range in temperature, and No. 9, which vitrified abruptly, showed an abrupt increase in strength at the same time.

As in the case of the specimens fired in the potteries, there was considerable variation in the maximum transverse strengths of the different bodies. The values varied from 9313 pounds per square inch for No. 8 to 5317 pounds per square inch for No. 1 and followed fairly closely the order in regard to the transverse strengths observed in the results on the specimens fired in the potteries.

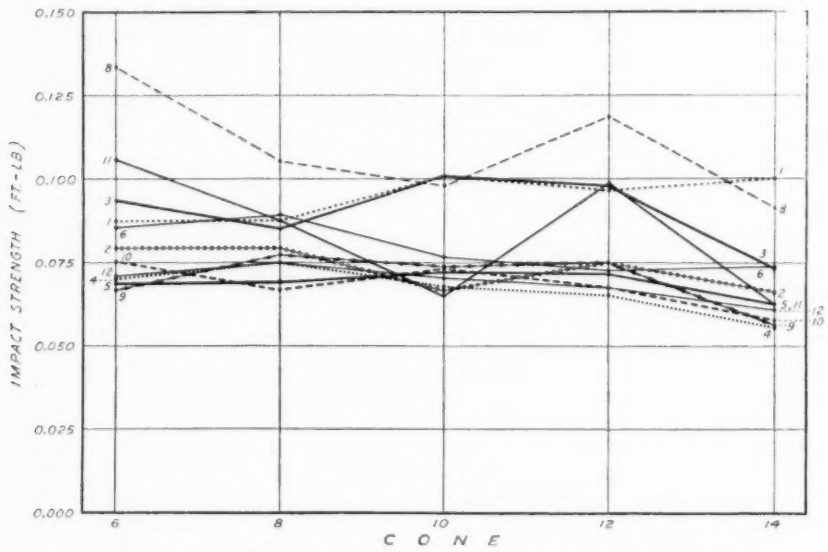


FIG. 18.—Results of impact tests on discs fired in the laboratory.

As in the compression tests previously described, the results obtained on the bodies fired in the smaller kiln, Fig. 17, were not as consistent as those for the moduli of rupture. According to expectations the greatest maximum compressive strength was that of No. 8. The loads per square inch causing failure of these specimens were very much lower than for the same bodies when given the slower firing and cooling in the pottery kilns.

The maximum compressive strength was found in bodies 2, 3, 5, 6, 8 and 9 when they were completely vitrified. Nos. 1 and 4 attained their maximum compressive strength at cone 12 and Nos. 10, 11 and 12 at cone 10, with porosities of from 3% to 4%.

In six instances the maximum compressive strength occurred at the same temperature as the highest modulus of rupture; in three cases it developed at a higher temperature, and in two bodies at a lower temperature.

The impact tests of the discs did not show consistent changes with

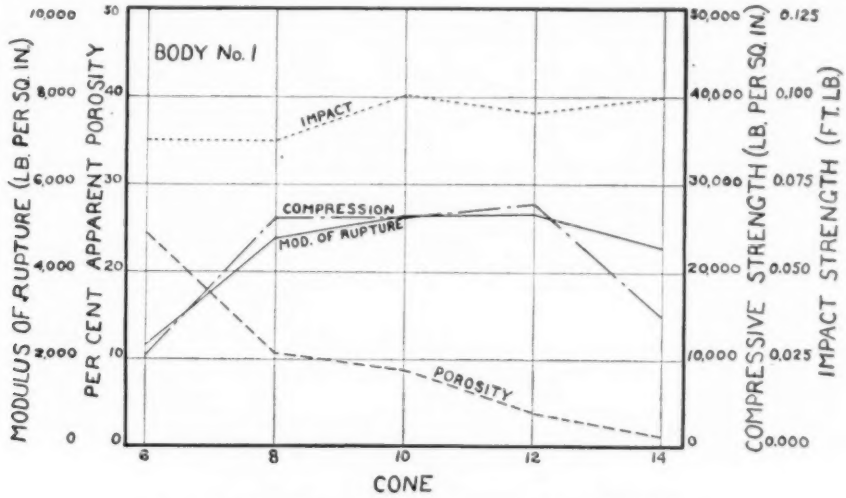


FIG. 19.—Results on body No. 1 fired in the laboratory.

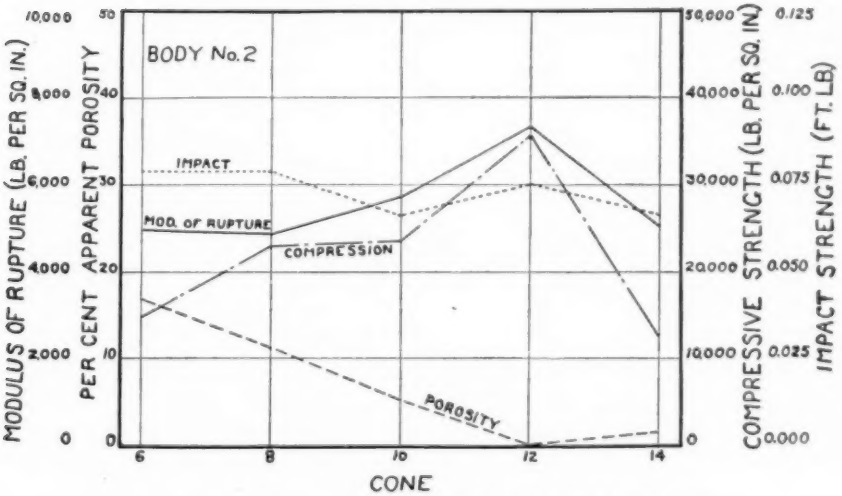


FIG. 20.—Results on body No. 2 fired in the laboratory.

increasing temperature except to indicate a reduction in the ability to withstand sudden blows as overfiring occurred. The greater strength of No. 8 appeared again in these results which are plotted in Fig. 18.

The change in transverse, compressive, and impact strengths and porosity with increasing temperature are shown collectively for each body in Figs. 19 to 29.

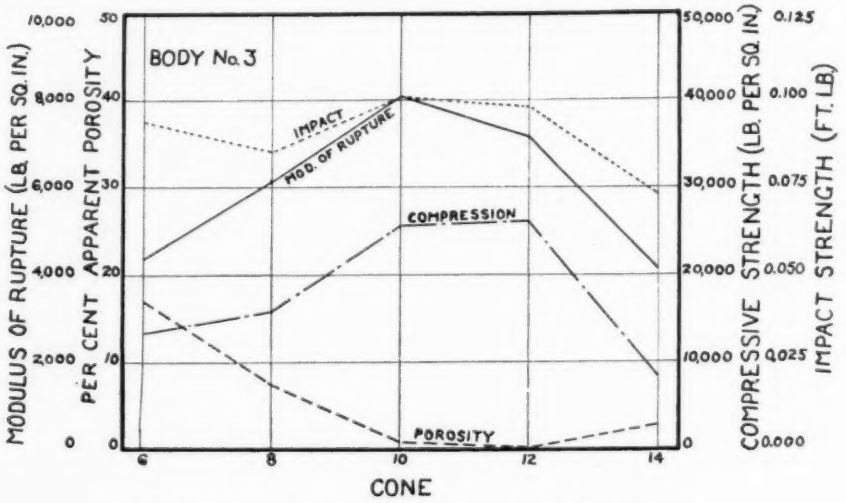


FIG. 21.—Results on body No. 3 fired in the laboratory.

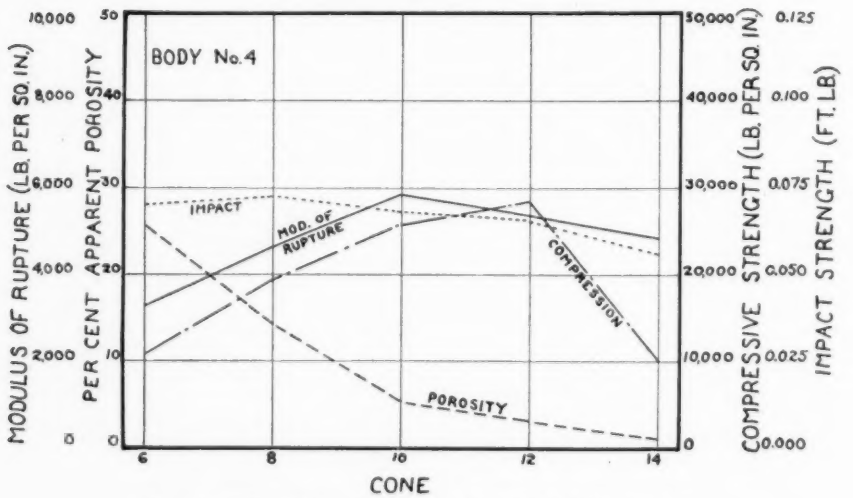


FIG. 22.—Results on body No. 4 fired in the laboratory.

Variations of two cones in firing treatment have a much greater effect on some commercial bodies of this type than on others. The range in temperature in which two of the bodies were vitrified and had high strength

was fairly wide. However, most of these commercial bodies became non-absorbent and attained their greatest strength within narrow limits in heat treatment, and in factory use require uniform firing conditions to produce bisque of near the same physical properties throughout a kiln.

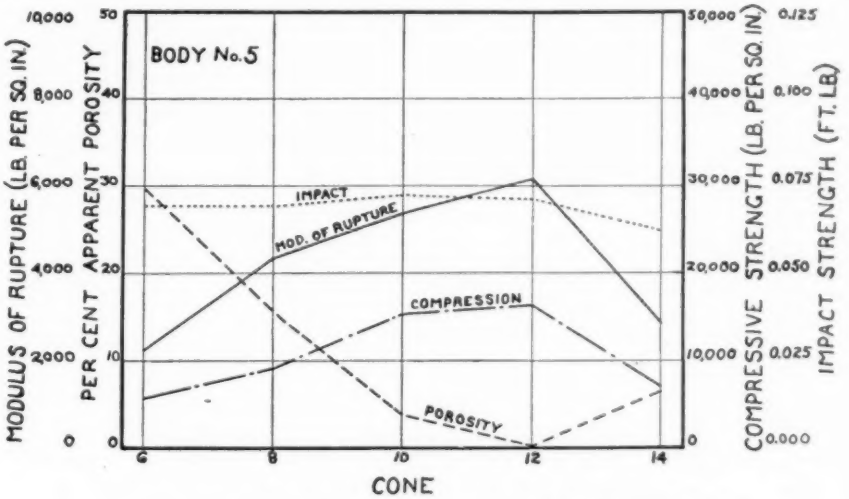


FIG. 23.—Results on body No. 5 fired in the laboratory.

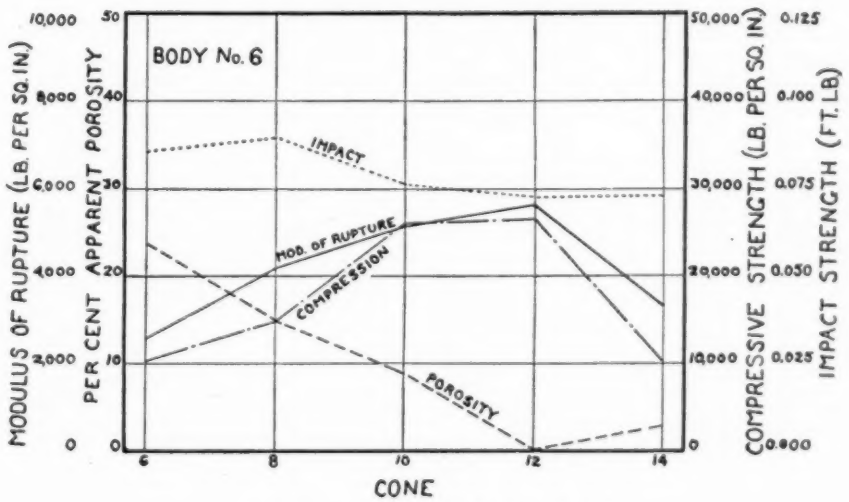


FIG. 24.—Results on body No. 6 fired in the laboratory.

The advantages of a body which will produce uniform ware in spite of the variations in kiln treatment are obvious, and the study of compositions from this standpoint by the potters is to be recommended.

Summary

In the ten pottery kilns studied, the bisque in six was uniformly vitrified. One kiln was slightly overfired and three were not fired quite hard enough to completely vitrify the specimens in the cooler parts of the kiln.

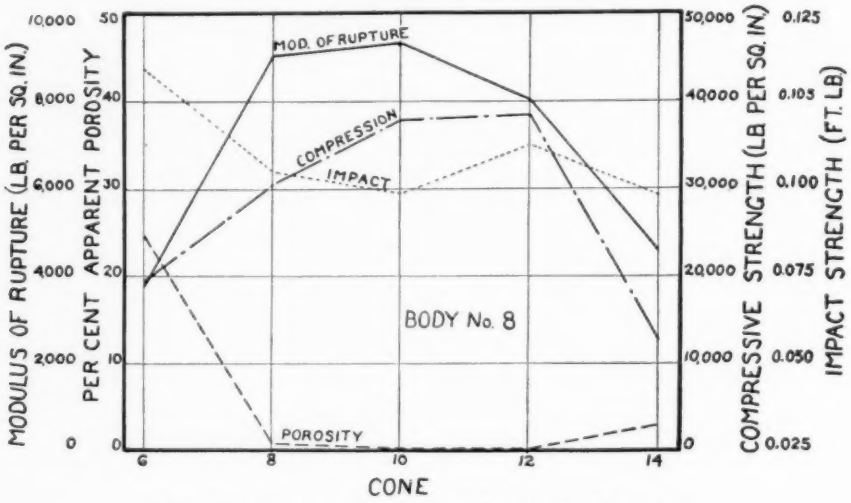


FIG. 25.—Results on body No. 8 fired in the laboratory.

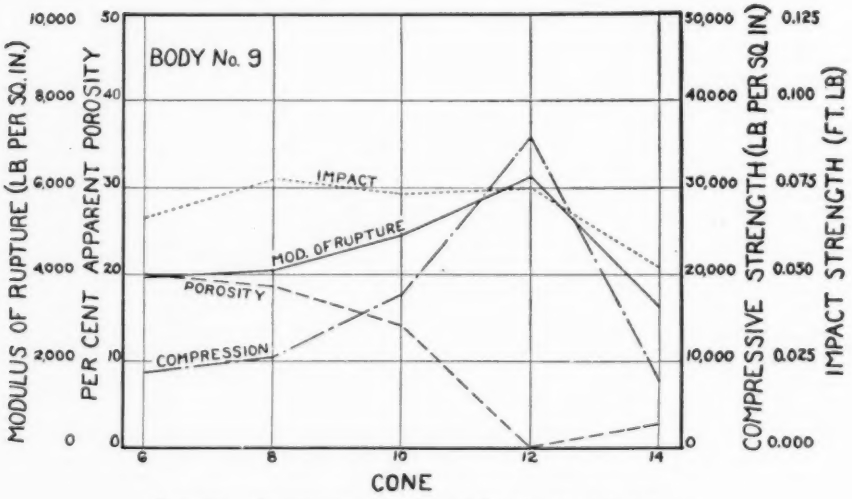


FIG. 26.—Results on body No. 9 fired in the laboratory.

The underfiring or overfiring of bodies of this type resulted in serious losses in strength when compared with that of the body properly vitrified.

While there was considerable difference in the maximum transverse,

compressive and impact strengths of the bodies, nearly all of them developed high strength when most advantageously fired.

The maximum strength existed over a narrower range in heat treatment than complete vitrification. The greater use in the potteries of tests of strength in the study of firing, compositions, and methods of body preparation would be of great help in raising the already high quality of American products.

The study of eleven bodies fired at temperatures of from cone 6 to cone 14 in the laboratory showed about the same differences in strength of the

TABLE I

RESULTS ON SPECIMENS FIRED IN POTTERIES

Number	Temperature	Bulk Specific Gravity	Per cent Absorption	Per cent Apparent Porosity	Modulus of Rupture (lbs. per sq. in.)	Compressive Strength (lbs. per sq. in.)	Impact Strength (ft. lbs.)	Average Thickness of Impact Specimens (inches)
1	H[1]	2.44	0.06	0.15	7403	45,130	0.0703	0.194
1	I	2.44	.26	.63	6310	37,490	.0791	.197
1	L	2.40	.91	2.18	6241	34,625	.0750	.199
2	H	2.35	.05	.11	6345	29,180	No discs made	
2	I	2.35	.05	.11	5864	30,380		
2	L	2.34	.06	.13	5960	30,820		
3	H	2.39	.00	.00	8118	57,290	.0910	.213
3	I	2.40	.00	.00	7985	55,440	.1089	.219
3	L	2.41	.00	.01	8402	62,125	.1071	.218
4	H	2.38	.08	.21	6486	38,170	.0750	.203
4	I	2.32	1.37	3.18	5306	32,805	.0850	.214
4	L	2.26	2.28	5.55	4586	30,750	.0859	.207
5	H	2.36	.04	.09	6994	46,970	.0734	.200
5	I	2.37	.05	.13	7070	48,125	.0875	.203
5	L	2.38	.05	.09	7604	59,440	.0946	.197
6	H	2.35	.02	.04	5896	61,320		
6	I	2.32	.35	.80	5231	52,050	No discs made	
6	L	2.26	2.22	5.01	4786	45,560		
7	H	2.37	.51	1.20	4975	33,080	.0725	.205
7	I	2.37	.59	1.38	4908	37,560	.0725	.205
7	L	2.36	.71	1.67	4693	34,090	.0750	.206
8	H	2.37	.02	.04	8453	68,930	.1604	.250
8	I	2.41	.02	.05	9105	57,950	.1791	.249
8	L	2.42	.02	.04	9444	55,780	.1725	.232
9	H	2.32	.11	.24	6296	21,260	.0688	.191
9	I	2.40	.01	.03	7830	34,490	.0729	.195
9	L	2.39	.02	.05	8106	51,080	.0833	.199
10	H	2.41	.02	.04	7456	45,090	.1025	.212
10	I	2.41	.06	.13	7462	38,170	.0979	.200
10	L	2.42	.04	.09	7967	36,650	.0825	.195

[1] The letters H, I, and L denote highest, intermediate, and lowest, respectively.

TABLE II

RESULTS ON SPECIMENS FIRED IN LABORATORY

Number	Cone	Bulk Specific Gravity	Per cent Absorption	Per cent Apparent Porosity	Modulus of Rupture (lbs. per sq. in.)	Compressive Strength (lbs. per sq. in.)	Impact Strength (ft. lbs.)	Average Thickness of Impact Specimens (inches)
1	6	1.93	12.67	24.34	2298	10,450	0.0875	0.220
1	8	2.23	4.73	10.59	4755	26,150	.0875	.224
1	10	2.30	3.78	8.72	5267	26,000	.1008	.225
1	12	2.40	1.58	3.86	5317	27,630	.0969	.222
1	14	2.12	.58	1.17	4557	14,920	.1000	.232
2	6	2.10	8.00	16.83	4987	14,820	.0792	.203
2	8	2.18	5.29	11.44	4872	23,080	.0792	.209
2	10	2.33	2.34	5.45	5717	23,650	.0663	.216
2	12	2.42	.02	.06	7363	35,560	.0750	.198
2	14	2.05	.91	1.86	5018	12,505	.0662	.212
3	6	2.07	6.58	16.94	4376	13,280	.0937	.200
3	8	2.33	3.23	7.37	6127	15,880	.0850	.174
3	10	2.36	.38	.89	8035	25,570	.1008	.171
3	12	2.36	.03	.08	7120	26,180	.0979	.170
3	14	1.94	1.52	2.90	4130	8,080	.0732	.195
4	6	1.91	13.99	25.51	3258	10,680	.0700	.200
4	8	2.13	6.73	14.32	4626	19,360	.0750	.184
4	10	2.33	2.28	5.33	5851	25,570	.0680	.178
4	12	2.35	1.35	3.16	5347	28,890	.0653	.175
4	14	2.10	.55	1.12	4862	10,110	.0555	.170
5	6	1.79	16.34	29.72	2249	5,620	.0688	.204
5	8	2.10	7.46	15.57	4358	9,204	.0688	.174
5	10	2.30	1.67	3.78	5374	15,270	.0725	.184
5	12	2.33	.06	.13	6154	16,370	.0714	.183
5	14	1.84	3.21	6.50	2897	7,710	.0625	.218
6	6	1.92	12.38	23.64	2600	10,250	.0854	.248
6	8	2.11	6.40	14.90	4161	14,850	.0896	.230
6	10	2.25	3.98	8.98	5108	26,000	.0764	.214
6	12	2.33	.07	.17	5614	26,630	.0725	.210
6	14	1.98	1.12	3.03	3333	10,064	.0734	.239
8	6	1.93	12.29	24.48	3794	19,450	.1344	.258
8	8	2.39	.33	.79	9033	30,450	.1050	.198
8	10	2.39	.02	.04	9313	37,860	.0979	.201
8	12	2.38	.02	.05	8008	38,380	.1188	.210
8	14	1.93	1.52	2.95	4283	12,560	.0919	.257
9	6	2.03	9.81	19.97	3937	8,730	.0666	.190
9	8	2.07	8.95	18.62	4107	10,500	.0775	.212
9	10	2.17	6.47	14.00	4911	17,700	.0734	.182
9	12	2.35	.07	.16	6253	35,880	.0750	.170
9	14	1.98	1.51	2.81	3239	7,680	.0521	.190
10	6	1.88	13.51	25.61	3217	10,510	.0750	.199
10	8	2.18	6.16	12.28	4896	17,180	.0666	.185
10	10	2.35	1.71	4.03	7521	23,171	.0725	.170

10	12	2.36	.14	.34	6037	16,460	.0675	.177
10	14	1.93	1.93	3.71	3425	9,990	.0575	.201
11	6	2.03	8.68	17.59	4192	12,730	.1054	.255
11	8	2.18	4.87	11.59	4376	27,700	.0875	.216
11	10	2.33	1.24	2.89	6121	28,600	.0650	.176
11	12	2.36	.10	.24	6418	21,920	.0986	.237
11	14	1.95	1.37	2.66	3208	8,990	.0625	.216
12	6	1.78	17.05	30.00	2374	14,730	.0719	.212
12	8	2.24	4.36	9.74	4280	17,680	.0750	.201
12	10	2.34	1.25	2.95	5279	36,150	.0700	.174
12	12	2.32	.06	.15	6350	20,220	.0675	.180
12	14	1.86	2.26	4.22	2881	11,120	.0607	.212

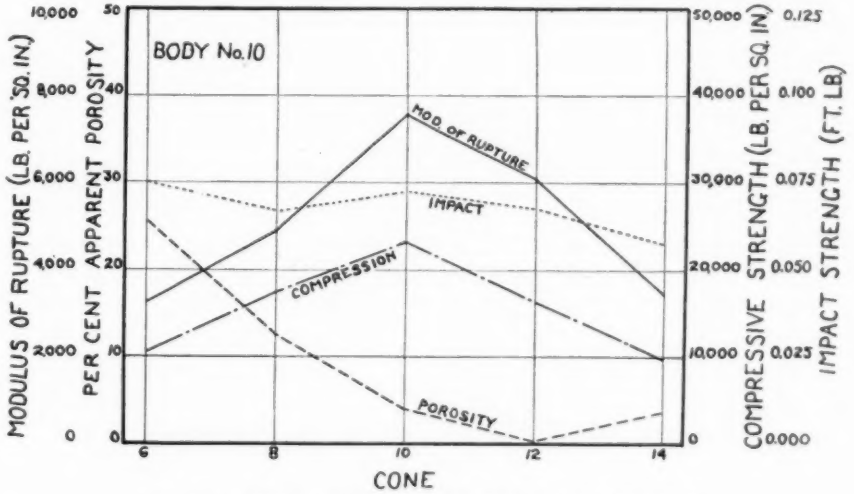


FIG. 27.—Results on body No. 10 fired in the laboratory.

bodies as the tests on the specimens fired in the pottery kilns. In one body only as high maximum strength was found in the specimens fired in the small kiln as in those fired in the factories.

In most cases the maximum strength was developed coincident with vitrification, and in all the bodies it occurred near or prior to cone 12.

Impact tests on discs did not show any consistent differences in impact strength with increasing temperature except to show a reduction with overfiring.

There was considerable difference in the bodies studied in regard to the temperature range over which they were vitrified and of greatest strength. While two of the bodies were excellent in this respect, the remainder were vitrified and of high strength only through a narrow range of cones.

The study of compositions and methods of body preparation from this standpoint is desirable. The Bureau of Standards is planning a study of this kind on porcelain bodies.

ACKNOWLEDGMENTS: The author wishes to thank Mr. C. E. Jackson, chairman of the American Vitrified China Manufacturers Association, and the members of the Association for their generous coöperation in the work, P. H. Bates for helpful advice in regard to the testing, and W. L. Shearer, R. B. Fair and John Stanley for assistance in the work in the laboratory.

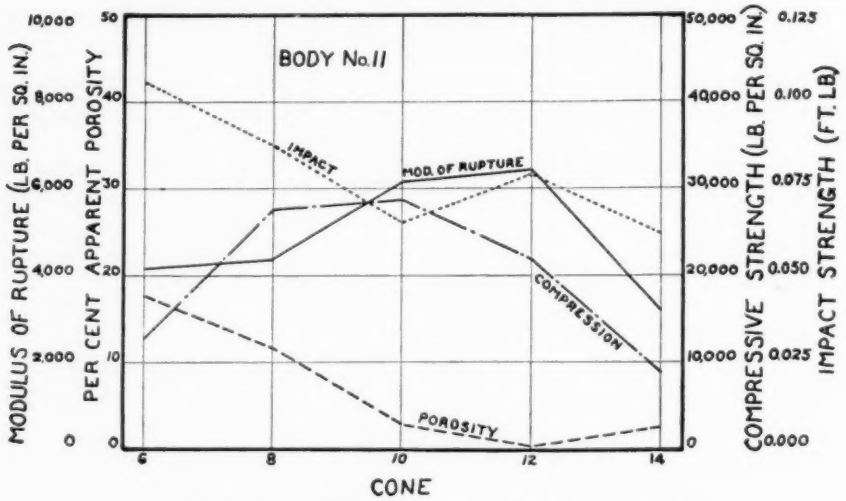


FIG. 28.—Results on body No. 11 fired in the laboratory.

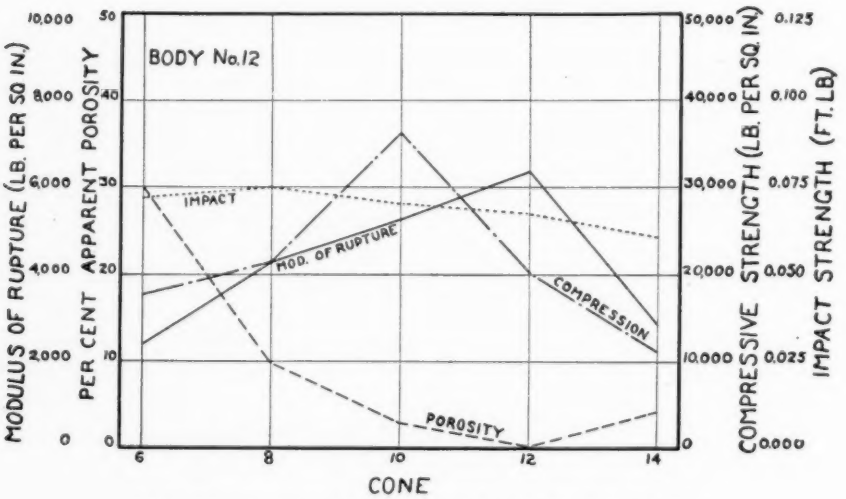


FIG. 29.—Results on body No. 12 fired in the laboratory.

A NEW RAW MATERIAL FOR CERAMIC USES

By Paul E. Cox and D. A. Moulton

ABSTRACT

A mineral, not heretofore reported, similar to feldspar in analysis but partially colloidal like bentonite, is described and some uses suggested for it. Analyses are shown and the properties are described. It should make a very useful material in bodies, glazes and enamels, as it has the properties of a feldspar and the plasticity of a fairly plastic clay.

Introduction

The writers were asked to determine the possible ceramic use of this new mineral from an analysis made by George W. Burke, chemical engineer, in charge of the analytical laboratories of the Engineering Experiment Station of Iowa State College, Ames, Ia.

Physical Tests

Slaking.—A lump of this material was dropped into water for the slaking test. It did not slake like clay but became a jelly-like mass like bentonite. Unlike bentonite only a part of it became jelly-like and it did not swell and fill the vessel. A considerable amount of the material was somewhat like a mixture of kaolin and rather small flat stones, though the stones were so covered with the colloidal portion that they felt at first as though, if time were given, they too would soften. This softening, however, did not occur.

A considerable sample was then placed in a stoneware jar, left to soften, and then lawned through a 100-mesh sieve. It was found that 40% (dry weight) would pass a 100-mesh sieve. The 40% that passed this sieve was colloidal, looking exactly like a well prepared starch paste. To the fingers a little grit was noticeable, but a very little bit of this 40% was other than colloidal.

Plasticity.—The colloidal material alone could be easily thrown on the wheel. Mixed with calcined Florida kaolin and the whole ground to pass a 100-mesh sieve it was found that vase forms could quite easily be thrown from the mixture.

This material would serve as a first rate substitute for feldspar and would be better than feldspar because it would add plasticity. There is no reason to separate the two parts of this mineral unless the benefit of maximum colloidality is desired for practical reasons.

This ought to be a specially useful material for glazes, enamels and abrasive wheels because it not only functions as does feldspar but it will serve to float the non-plastic grains.

Fusion.—The two parts of this mineral were tested for the fusion points in a carbon resistance furnace.

The colloidal part fused down between cones 7 and 8, while the crystalline

part fused down at about cone 6. The crystalline part had been ground for about twenty hours in a ball mill, all of it readily passing a 100-mesh sieve. When the cone of this crystalline material was taken from the furnace it was found to be dark brown in color, like Albany slip. Repeated tests, with every precaution against contamination gave the same results. Inasmuch as the Orton cones are made from materials that analyze somewhat as this mineral, and in the same tests, they were white as usual, Mr. Burke's analysis was suspected and the material was re-tested.

The colloidal part yielded a light gray fusion. Mr. Burke's analyses are as follows:—

CHEMICAL ANALYSES

Analysis of whole sample		Held by 100-mesh	Passed 100-mesh
SiO_2	67.84	68.46	63.60
Fe_2O_3	15.43	0.64	2.15
Al_2O_3		13.72	15.82
TiO_2		0.15	0.20
P_2O_5		0.59	0.35
CaO	0.82	1.59	1.13
MgO	1.33	2.05	0.54
Na_2O	5.01	6.77	5.51
K_2O			
H_2O	9.57	6.03	10.90
MnO		.01	0.017

It seems hard to believe that in the part held on the 100-mesh sieve there was colorant enough of any sort to yield an almost jet black cone, even with the reduction incident to a fusion in a carbon resistance furnace.[1]

Test in Glazes

That part held on the 100-mesh sieve was used in compounding a bright glaze, designed to mature at cone 03, consisting of 40% of this non-colloidal material and 60% of white lead. This glaze was dipped on dry pressed white biscuit tiles, and on a tile made in the plastic way, (a rolled-out bit of clay) from an Iowa shale. The samples were fired in a small electric furnace in about seven hours, yielding perfect glazes, with no crazing on the shale sample and some crazing on the lightly fired white biscuit tiles. A commercial test of this glaze stained with copper oxide on flower bowls gave perfect results in an 18-hour burn.

The resulting glazes show nothing of the black or brown, though on the deeper modeling of the white tiles a warm yellow shows, though not deeper than is commonly seen in glazes rich in lead oxide. This verifies the truth of Mr. Burke's analyses and it would pay the glaze and body makers to investigate this material.

[1] The writers would like to have this point cleared by those experienced in the handling of porcelains under reducing conditions.

Origin

S. L. Galpin, of the Department of Geology of Iowa State College believes that this mineral is a decomposed granite or a decomposed granitic rock. Dr. Galpin referred the writers to *Bulletin 708* of the U. S. Geological Survey in which reference is made to *clays* in the neighborhood of Beatty, Nevada, which place is the location of the mineral under discussion. On page 124 of this *Bulletin* are described in detail deposits of clays that were shipped to California potteries from time to time but the properties described are not at all like those of the sample under discussion. For example the statement is made of one of them that the clay was gritty, would not slake down to any degree in water, and that when ground to pass a 20-mesh sieve there was no plasticity. Of another one, page 125, it is said that a very plastic sticky mass resulted, but that it burned to a very white and *porous* body at *cone 10*. No analyses are shown in the *Bulletin*.

Quantity Available

The question then would be as to the extent of the deposit and the uniformity of output possible. A letter to the owner brought a statement that two mineral claims of about twenty acres each comprise the deposit, and that the mineral occurs in six vertical veins of from 6 to 10 feet in width. Outcroppings show these veins to cut clear through the hill from side to side, and it is estimated that they extend to a depth of 3000 feet. The quantity seems sufficient for a time anyhow.

The owner says that a shaft has been dug both horizontally and downward for some distance and that the quality seems to be uniform. It lies on a railroad.

Conclusion

It appears to the writers that this is an even better material than Cornwall stone, because it is much more plastic. It functions as a feldspar in glass, glaze and body, but with the properties of a clay. It appears that there is enough of it to make it worth while. Further work might show that this is the long desired clear slip glaze that was always the desire of the old time stoneware potter to find and the writers expect to continue work, making use of the colloidal part in glaze and enamel work, as has already been done in a small way in body work. It will make a nonplastic material like flint or feldspar plastic, taking a part of the load off the ball clay and kaolin.

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THE PROPERTIES OF SOME CLAY-LIKE MATERIALS OF THE BENTONITE TYPE[1]

By H. G. Schurecht and H. W. Douda

ABSTRACT

The evidence obtained in this work would indicate that bentonites are mixtures of two or more materials rather than one. The exact composition of these is not known but they are probably mixtures of colloidal silicates and fine-grained kaolinite in varying proportions.

They are characterized by the following properties: Conchoidal fracture; an index of refraction between 1.48 and 1.54; high water of plasticity and volume drying, shrinkage varying from that of highly plastic clays to 114.61% and 195.9%, respectively; and a high alkali plus alkali earth content, usually above 5%. When added in small amounts to certain clays, some bentonites increase the dry strength to a remarkable extent. In firing they vitrify between 1000°C, soften at cones 1–14 and burn to a buff to brown color and therefore can only be used in small amounts in white ware.

It is possible by adding finely ground quartz and small amounts of bentonite to certain fire clays to produce mixtures approaching the Arkansas and certain other glass pot clays in physical properties and in index of refraction. Adding too much bentonite to clays causes them to crack in drying.

Introduction

Large deposits of clay-like materials are found, principally west of the Mississippi River, known as bentonite, which are characterized by unusual colloidal properties, being much superior to true clays in this respect.

Bentonite was described by Knight[2] under the name of "taylorite," who, upon finding that this name was already in use changed it to bentonite,[3] since it occurred in the Benton formation. Knight also pointed out that it resembled ehrenbergite of Germany. Some of the similar materials are montmorillonite, halloysite and leverrierite. "Wilkenite" and "ardmorite" are trade names used to describe particular bentonites.

It is claimed by Dumble[4] that materials similar to bentonite in Texas were derived from volcanic products. Read[5] states that the bentonites of Wyoming were derived from the decomposition of feldspar, labradorite, occurring in the anorthosite of the Laramie mountains.

Most bentonites[6] of Wyoming occur in the Benton and Niobrara forma-

[1] Published by permission of the Director, U. S. Bureau of Mines. Presented at the meeting of The American Ceramic Society, St. Louis, Mo., Feb., 1922.

[2] W. C. Knight, *Eng. Min. Jour.*, **63,** 600 (1898).

[3] *Eng. Min. Jour.*, **66,** 491 (1901).

[4] W. H. Zimmer, "Hydrated Silicic Acid in Kaolin and its Effect on Pottery," *Trans. Amer. Ceram. Soc.*, **3,** 40 (1901).

[5] George P. Merrill, "The Non-Metallic Minerals," John Wiley & Sons, N. Y., 243 (1905).

[6] H. Ries, "Occurrence, Properties, and Uses of Clays," John Wiley & Sons, N. Y., 209 (1908).

tions of the Cretaceous period. Deposits are also reported[1] in the Cretaceous and Tertiary periods in the north west and in the Cretaceous period of the great plains region of Canada. As a rule, bentonites occur in the younger geological formations, which may account for their high collodial content as compared to clays occurring in the older geological periods from which most of the colloidal matter has been washed through weathering.

Bentonite-like substances occur in Wyoming, California, South Dakota, Montana, Arizona, Utah, Texas, Colorado, Mississippi, and Nevada. Other deposits are reported by Ladoo[2] in New Mexico and in the Ednaonton formation of the Red Deer River, and in the Nicola Valley, B. C. The prices vary from six dollars to thirty dollars per ton in carload lots.

Its use in ceramics up to the present time is limited. It was found by Zimmer[3] that similar clays, when added to ceramic bodies, produced more translucent porcelains than kaolin, although the shrinkage is excessive. Because of the unusual colloidal properties of bentonite, the Bureau of Mines is investigating the possible uses of this material as an ingredient in ceramic bodies.

Experimental Methods

The following properties were determined on a number of bentonites and also on some clays for comparison.

1. Index of refraction.
2. Per cent water lost by drying at 110°C.
3. Softening point, cones.
4. Per cent water of plasticity.
5. Per cent volume drying shrinkage.
6. Drying behavior.
7. Color when fired at 1000°C.
8. Strength when added to ceramic bodies.

The indices of refraction were determined with a petrographic microscope, using the Becke line method.

The water lost on drying the air-dry samples at 110°C was determined by first drying the raw bentonite at room temperatures and then at 110°C. The water lost was expressed in terms of the original weight. The softening points were determined by comparison with Orton cones. The water of plasticity and volume drying shrinkage were expressed in terms of the dry weight and volume of the clays respectively.

[1] E. Orton, Jr., "Experiments on the Drying of Certain Tertiary Clays," *Trans. Amer. Ceram. Soc.*, **13,** 782 (1911); J. Keele, "Drying Defects in Some Cretaceous Clays of the Great Plain Region of Canada," *Trans. Amer. Ceram. Soc.*, **14,** 158–60 (1912).

[2] R. B. Ladoo, "Bentonite," Bur. of Mines, *Repts. of Investigations*, October, (1921).

[3] W. H. Zimmer, *Loc. cit.*, 25–45.

The effects of additions of bentonite to 1:1 flint-kaolin mixtures were also studied, and, in this connection, the strength was determined in the dry state and the color and vitrification after firing were studied.

TABLE I

CHEMICAL ANALYSES OF BENTONITES[1]

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
SiO_2	60.64	57.98	58.68	59.84	60.18	63.20	54.00	55.22
Al_2O_3	23.26	22.46	25.91	11.84	26.58	12.90	24.48	21.00
Fe_2O_3	3.92	3.80	3.97	3.26	...	2.46	3.00	3.61
TiO_2	0.12	...	0	...	...	0.11	...	...
CaO	0.59	1.92	1.45	2.90	0.23	0.82	2.08	4.94
MgO	2.19	3.24	1.49	2.32	1.01	2.09	2.75	3.04
K_2O	0.37	1.35	0	2.34	1.23	0.26	...	...
Na_2O	4.33	...	1.39	2.13	...	0.66	1.74	1.56
SO_3	...	0.75	0.11	...	...	...	...	0.43
CO_2	...	...	tr.	...	...	3.50	...	tr.
Cl	...	...	0.10	...	...	0.20	...	0
P_2O_5	...	...	0.06	...	...	...	0.71	...
Ing. loss	...	7.93	...	10.50	...	...	...	...
H_2O	2.83	...	6.84	...	10.26	13.80	9.12	10.28
Total	98.25	99.43	100.00	95.13	99.49	100.00	97.88	100.08

[1] R. B. Ladoo, *loc. cit.*

No. 1. Yellow, colloidal; Belle Fourche, South Dakota, Analyst, W. A. Selvig, Bur. Mines.

No. 2. Yellow, colloidal; Medicine Bow, Wyo., Analyst, A. G. Van Eman, Owyhee Chemical Products Co., Chicago, Ill.

No. 3. White, colloidal; near Barstow, California, Analysis from Calif. Master Products Co., Los Angeles, Calif.

No. 4. White, fine grained; Otay, San Diego County, Calif.; analysis from Otaylite Products Co., Los Angeles, Calif.

No. 5. Type of material from near Rock Creek, Laramie Basin, Wyo., T. T. Read. Cassa Mining Co.

No. 6. From Big Horn Basin, Wyoming, Analyst, R. C. Wells, U. S. Geol. Survey.

No. 7. Supposed bentonite, near Shelbyville, Tenn. Analyst unknown.

No. 8. "Ardmorite," probable variety of bentonite; Ardmore, S. D. Analysis from the Refinite Co., Omaha, Neb.

Results

Color.—The color of raw bentonite varies widely in different deposits. It may assume the white cream, buff, green, yellow, pink, brown and even to black color, being similar to clays in this respect.

Fracture.—The fracture of different varieties varies from earthy to conchoidal. The conchoidal fracture, however, is more characteristic of bentonites than of plastic clays.

Hardness.—The hardness of different varieties is between 1 and 1.5.

TABLE II

PROPERTIES OF SOME CLAY-LIKE MINERALS OF THE BENTONITE TYPE

No.	Source	Index of refraction	Per cent water lost by drying samples dried at room temp. 110°C	Softening point cones	Per cent water of plasticity in terms of dry weight	Per cent volume shrinkage in terms of dry volume	Drying behavior	Color when fired at 100°C
1	Sanders, Ariz.	1.480	16.60	3	71.83	69.08	Cracks badly	Buff
2	Daggett, Cal.	1.495–1.505	14.87	8	69.52	94.21	Cracks badly[1]	Buff
3	Creede, Colo. No. 1	1.505	14.93	12	48.07	59.00	Cracks	Buff
4	Lovelock, Nev.	1.505–1.525	10.82	12	78.10	77.26	Does not crack	Buff
5	Unknown	1.5075	16.62	9	58.63	82.57	Cracks badly[1]	Buff
6	Source unknown	1.515–1.525	9.40	3	....	....	....	Brown
7	Newcastle, Wyo.	1.5175	7.26	9	114.61	161.39	Cracks badly[1]	Buff
8	Wyoming	1.5175–1.5375	9.25	4	99.21	162.73	Cracks badly and warps	Brown
9	Belle Fourche, S. Dak.	1.525–1.535	8.79	12	108.07	195.81	Cracks badly[1]	Buff
10	Creede, Colo., No. 2	1.545	1.83	12	37.30	30.16	Does not crack	Buff
11	Enid, Miss.	1.5475	4.64	14	46.16	73.25	Does not crack	Buff
12	Camden, Ark.	1.5575	2.19	27	37.30	41.94	Does not crack	White
13	Gross Almerode clay, Germany	1.5600	1.34	27	22.07	24.21	Does not crack	White
14	Las Vegas, Nev.	1.560	1.68	30	....	....	....	White
15	Glass pot clay, source unknown	1.5615	3.02	29	36.08	41.94	Does not crack	White
16	Houston, Tex.	1.563	0.27	34	....	....	....	White
17	Enid, Miss.	1.563	3.25	30,	29.75	32.13	Does not crack	White
18	New York	1.570	4.55	1	40.97	47.38	Does not crack	Buff

[1] These bentonites become very hard on drying.

TABLE III

THE EFFECT OF BENTONITE ADDITIONS ON THE PROPERTIES OF 1:1 FLINT-KAOLIN MIXTURES

Mixture number	Composition of mixtures			Modulus of rupture, lbs. per sq. in.	Mixtures fired at 1000°C Per cent apparent porosity	Color
	Flint	Kaolin	Bentonite			
1	50	50	0	43.87	39.42	Good white
2	50	50	6	87.01	38.90	Good white
3	50	50	15	158.84	37.72	Fair white
4	50	50	24	222.01	38.13	Cream
5	50	50	32	319.37	37.64	Buff

As a rule, bentonites are harder than ball clays, although there are a number of bentonites which are not quite so hard.

Chemical Properties.—The chemical analyses of a number of bentonites are shown in Table I. They are characterized by a high silica content, 54% to 63.2%, a high alkali plus alkali earth content, 2.46% to 9.69%, and a high iron oxide content, 2.46% to 3.97%. Many clays differ from bentonites in having lower alkali, alkali earth and silica contents, although there are also many clays which have similar chemical analyses.

It was reported by Zimmer[1] and Pence[2] that clays similar to bentonite contain hydrated silica. Although it is not definitely known, in what form the silica is present in bentonite, the evidence collected in this work would indicate that these substances have properties similar to alkali silicates or alkali-aluminum silicates mixed with clay in varying proportions. Bentonites vary in composition from those containing only 11% Al_2O_3 to those having almost the same composition as kaolinite. Those having a composition approaching kaolinite have properties which also approach those of true clays. It is, therefore, difficult to state which materials should be classed as bentonite and which should be classed as clays since it is possible that bentonites are simply mixtures of certain colloidal silicates and fine grained kaolinite particles in varying proportion although this has not yet been definitely proved. The gelatinous properties of this substance are not destroyed upon drying as would be the case with pure hydrated silica, but they regain this property upon mixing with water, probably due to the presence of alkali silicates.

Some bentonites dried at room temperatures lost 16.60% water upon a second drying at 110°C. Clays treated in a similar manner seldom lose over 5% water, hence in this respect bentonites are different from clays, due to their fine grains and hence higher adsorptive properties.

Drying Behavior.—The per cent water required to render bentonites

[1] W. H. Zimmer, *op. cit.*, 25–45.

[2] F. K. Pence, "The Determination of Hydrated Silicic Acid in Clay," *Trans. Amer. Ceram. Soc.*, **12**, 43–53 (1901).

plastic varies from that required for highly plastic clays up to 114.61%, (see Table II). The volume drying shrinkage varies from that of highly plastic clays up to 195.81%. As a rule bentonites require much more water to render them plastic and have a higher drying shrinkage than clays.

They crack badly upon drying, forming at first a network of fine cracks, which open up as drying proceeds. It was pointed out by Orton[1] and Keele[2] that bentonite frequently occurs in streaks ranging from one inch up to several feet in thickness among the clays of the Cretaceous and Tertiary periods, and that the poor drying properties of these clays are attributed to the presence of bentonite. Orton reports a high hygroscopic water content, which is probably due to the presence of bentonites, which have a higher content of this water than true clays.

When mixed with sufficient non-plastic ingredients their drying properties are greatly improved.

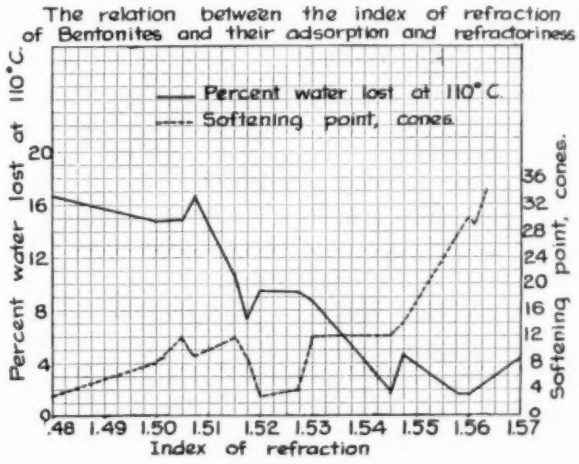

FIG. 1.

When treated with HCl and dried, some bentonites act similar to alkali silicates. For example, when sodium silicate is acidified with HCl and dried at 110°C, it forms H_2SiO_3 and NaCl as is shown below:

$$Na_2SiO_3 + 2HCl = H_2SiO_3 + 2NaCl$$

The silicic acid after drying becomes set and when remixed with water does not become gelatinous. Likewise if certain bentonites are acidified with hydrochloric acid, dried at 110°C and then remixed with water they lose considerable of their gelatinous properties and after this treatment have a much lower drying shrinkage than the untreated bentonite.

[1] E. Orton, Jr., *op. cit.*, 781–784.

[2] J. Keele, *op. cit.*, 158.

When suspended in water, bentonites often swell to six times their original bulk volume, as is shown in Fig. 3. The sample on the right shows the volume of a cube of bentonite before soaking in water, and that on the left a similar cube after being suspended in water by means of a wire basket for 12 hours.

Microscopic Properties.—Under the microscope bentonite appears as homogeneous aggregates of extremely fine particles. These particles often cannot be distinguished unless a magnification of 1000 to 1200 X is used.

The following properties of bentonite were obtained by Dr. Leon C. Haven,[1] of the Department of Hygiene, of the Johns Hopkins University, Baltimore, Maryland, using oil immersion lens.

Size of Particles.—Wyoming sample (Owyhee Chemical Products Company), particles range in size from ultra microscopic to 4–5μ. A great majority of grains from 0.1–0.5μ.

California Sample (California Master Products Corp.).—Particles very much smaller on the whole than Wyoming sample. None larger than 1μ. Fully $^1/_2$ ultramicroscopic or just within range of vision of 1200 X magnification. General run about 0.1–0.2μ. Particles more uniform in size than Wyoming specimens. Not such a range of sizes.

The indices of refraction vary with different varieties from 1.48 up to those approaching kaolinite, 1.563 (see Table II). Those materials having the lowest index of refraction as a rule have the most highly developed colloidal properties. The per cent water adsorbed by the material in general increases and the softening point decreases with a decrease in the index of refraction (see Fig. 1). The index of refraction of hydrated silica varies from 1.40–1.45 and that of certain alkali silicates is only slightly higher. It is possible, therefore, that the lower index of refraction of bentonite is partly due to the presence of similar silicates intimately mixed with fine grained kaolinite, since it was found that by adding sodium silicate to Georgia clay, the index of refraction is lowered in proportion to the amount of silicate added.

Owing to the extreme fineness of grain of bentonite, it was suggested that this lower index of refraction might be due to a high content of adsorbed water. Samples of bentonite and Georgia clay were, therefore, calcined to different temperatures, their indices of refraction determined, and the results were obtained as shown in the table.

It is obvious that even after heating to a red heat, the index of refraction of bentonite does not reach that of kaolinite. A small increase from 1.475 to 1.490 caused by drying the air-dry bentonite at 110°C may be due to driving off the adsorbed water.

[1] Written communication to Raymond B. Ladoo, U. S. Bur. Mines, Washington, D. C.

Refractoriness.—Bentonites vary in softening points from cones 1–14. This low refractoriness, as compared to kaolins, is due to the presence of considerable alkalies, alkali earths, and iron oxide, which act as fluxes, and to the extremely fine grained character of this substance. In

Drying and calcination temp. °C	Index of refraction of Bentonite	Index of Refraction of Georgia kaolin
20	1.475	1.563
110	1.490	1.570
225	1.490	1.570
300	1.498	1.570
325	1.5325	1.570
350	1.5325	1.570
375	1.5325	1.570
400	1.5325	1.570
425	1.5325	1.570
450	1.5425	1.570
500	1.5450	1.570
550	1.5375	1.565
600	1.5375	1.560

this respect many clays differ from bentonites, since they often soften above cone 27, although a number of clays also soften at cones 1–14.

Color When Fired.—The color of bentonites, when fired at 1000°C, varies from buff to brown (see Table II). Since clays often burn to a pure

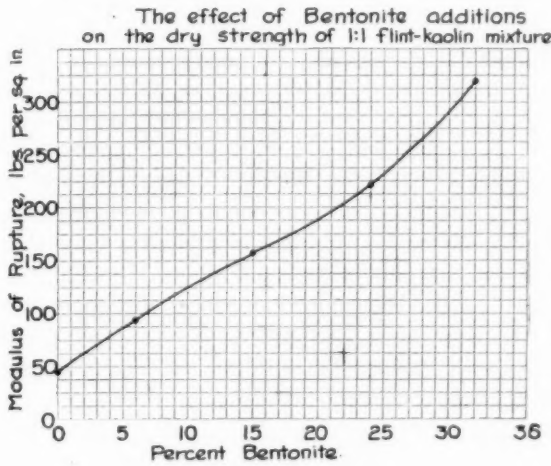

FIG. 2.

white color, they are different from bentonite, which seldom do. A certain amount of bentonite may be added to 1:1 flint-kaolin mixtures without ruining the color (see Table III). The buff color of the bentonite in mixtures containing a low percentage of this material is concealed by

the kaolin since bentonites are fine-grained and become more intimately mixed with the kaolin than if it were coarser grained. Bentonite, if used in whiteware, should, therefore, be added in small amounts only.

Possible Utilization of Bentonite in Ceramics

Comparison of Bentonites with Some Bond Clays.—Sample number 12 (see Table II), is a glass pot clay from Camden, Arkansas. This clay was examined under the microscope and found to contain considerable creptalline quartz. The index of refraction was found to be 1.5575 instead of 1.563, which is the index of refraction of kaolinite. The lower index of this clay may be due to the presence of a bentonite-like substance in small amounts.

Clay No. 11 was reported as being extremely strong in the raw state, but non-refractory. The index of refraction is 1.5475 instead of 1.563, which may also indicate the presence of a bentonite-like substance, hence causing its high dry strength. The alkali and iron oxide which are usually present in high percentages in bentonite would cause its low refractoriness.

FIG. 3.

Because of its extreme fineness and the ability of some varieties to remain in suspension for long periods of time, it has been suggested that this material may be used to keep glazes and enamels in suspension. If employed in too great amounts, however, it would cause excessive cracking of the glaze due to its high shrinkage.

The Effect of Bentonite Additions on 1:1 Flint-Kaolin Mixtures

In Figure 2 and Table III are shown the results of bentonite additions to 1:1 flint-kaolin mixtures. The per cent increase in strength is directly proportional to the amount of bentonite added until 25% is employed. $S = KB$ where S is the modulus of rupture in pounds per square inch; B is the per cent bentonite added, and K is a constant for this bentonite. Sample 1 was used in these tests, and whether all bentonites act in this manner remains to be proven.

It may be possible to make synthetic glass-pot clays approaching the Arkansas clays in properties by adding quartz and a small amount of bentonite to certain fire clays. Adding too much bentonite would cause the clay to crack in drying, due to the excessive shrinkage of this substance.

NOTE: The writers wish to acknowledge their indebtedness to R. T. Stull for suggestions and help in the progress of this work.

CERAMIC EXPERIMENT STATION
U. S. BUREAU OF MINES
COLUMBUS, OHIO

CERAMIC ABSTRACTS

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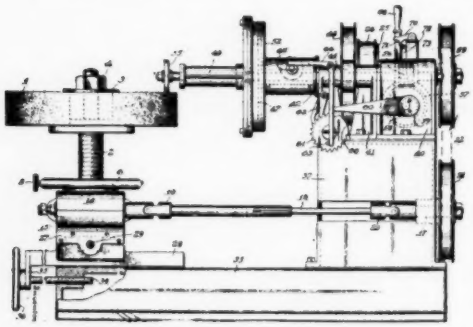
[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

Abrasives

PATENTS

1. Process of manufacturing aluminous abrasives. THOMAS B. ALLEN. U. S. 1,448,586, Mar. 13. The process of manuf. of aluminous abrasive, which consists in smelting an aluminous ore with aluminium by means of electrically developed heat.

2. Grinding-wheel-test device. HARLEY H. LA VERCOMBE. U. S. 1,446,977, Feb. 27. A machine for detg. the grade of abrasive bodies, having in combination means for supporting a body, a disk, power actuated means for rotating the disk in contact with the body, and means for moving the disk away from the body when the disk has been given a predetermined number of rotations, said means for moving the disk away from the body being controlled by the means causing rotation of the disk.



3. Nonslip quartz tile. MACDONALD C. BOOZE. U. S. 1,451,456, Apr. 13. A non-slip tile comprising abrasive quartz granules and a ceram. bond uniting said grains into an integral, wear-resisting mass in which the grains form the major portion of the tread surface, said bond being more wearable than the quartz and capable of permitting renewal of the tread anti-slipping characteristics under a normal usage.

Art

4. Colored glazes in the ceramic industry. ANON. *Chem. Trades Jour. and Chem. Eng.*, **72,** 570(1923).—Utilization of the less common metals, for decorative ceramics: The oxides and compds. dealt with in this article are those of uranium titanium, cerium and allied metals, zirconium and tungsten; and they will be considered solely as constituents of glazes and enamels. Uranium compds. are of great value as the oxide of uranium can produce varying colors, depending upon the nature of the glaze and the conditions of working. The yellow oxide, or sodium uranate, gives a deep orange color in combination with a lead glaze, but with leadless or low-lead glazes, the color produced is lemon yellow, particularly in the presence of boric acid. In general, the greater the amt. of lead in the glaze, the richer is the orange color for a constant amt. of uranium. The color produced in lead glazes is not necessarily orange, for a peculiarly rich vermillion red has been produced by the use of certain propns. of sodium uranate in a lead glaze contg. zinc oxide. At high temp. (cone 8) uranium is said to be suitable for the production of colors in leadless glazes, but is somewhat difficult to use. The yellow oxide is the most suitable in porcelain glazes, maturing at cone 10, sodium uranate gives pleasing light yellow colors, but only a slight increase in color is brought about by a considerable increase in the amt. of uranium. In such glazes pleasing slate colors can be produced by glazes containing oxides of cobalt and uranium. At lower temps. green glazes can be made by blending cobalt and uranium oxides in suitable propns., and with these glazes there appears to be no danger of that discoloration often produced by the more common green chromium glazes. One of the effects of the addn. of a little cobalt seems also to be the prevention of the irregularity of color often produced by uranium alone. When fired under reducing conditions porcelain glazes contg. from

10 to 15% of black uranium oxide give brilliant but expensive jet blacks. Sol. salts of uranium are sometimes employed as under or over-glaze colors. As an under-glaze color, uranium nitrate, with a suitable base, gives good yellows under oxidizing and neutral conditions, and good greys and blacks in reducing atmosphere. As an over-glaze color, uranium nitrate has been employed in polychrome terra-cotta, the ware being first sprayed with the glaze or slip to be used as a base and the soln. of the sol. salt being applied to the required area by hand painting. It has been found that a soln. in glycerin gives the best results, since water alone allows the brush marks to show, while glycerin is not absorbed so quickly and thus permits the successive brush marks to mingle. Suitable dyes can be used to show the painted areas. Pleasing colors have been obtained by combining uranium nitrate with nitrates of iron, manganese and chromium, and with sulphate of cobalt. With the high uranium and low cobalt, greens are obtained, while with lower uranium and higher cobalt, blue glazes are produced. In combination with vanadium, as uranium vanadate, uranium is said to give an old ivory effect. The resinates of uranium, sometimes in combination with those of iron, bismuth, or gold, are used for the production of colored lusters. Titanium dioxide has been used to some extent as a coloring agent in porcelain glazes. It has been found that the addn. of 5% of C. P. titanium dioxide gives a pleasing light yellowish tint to a porcelain glaze, while the addn. of a further 5% intensifies the color to a deeper straw. 5% rutile in a similar glaze gives a good light corn yellow, while 10% gives a deeper color; but it is possible that in the last case the color may be partly due to ferruginous impurity in the rutile. When painted on the surface of a felspathic slip rutile gives good light buff and buff browns, but in this case also the color may be due mainly to iron. In combination with cobalt and a little oxide of iron, rutile can yield excellent greens, though the color is not quite so bright as that obtained in the presence of some uranium. The most promising field for the use of titanium oxide in glazes appears to be in the development of those of a cryst. nature. Extremely beautiful cryst. effects have been produced in stoneware glazes by the use of rutile; and the addn. of small quantities of the oxides of molybdenum, tungsten, vanadium or uranium has been found to promote the development of the crystals and to give pleasing colorations. Wonderful cryst. effects have also been produced by introducing rutile into a china glaze contg. zinc oxide, and the titanium appears to be essential for the production of good crystals. Titanium dioxide has been found to be a useful opacifying agent for enamels, since it produces unusual durability and a very glossy surface which is resistant to abrasion. Cerium and allied metals: little information, beyond scattered references, chiefly in German lit., is available regarding the use of cerium compds. in glazes. Calcined cerium phosphate, after fritting with niter at cone 13 is said to yield at temps. between cones 9 and 14, with felspathic and other glazes, brilliant yellows which are resistant to oxidizing and reducing conditions. Cerium carbonate and cerium oxide (from the calcination of the oxalate) have been found to give good results when used as opacifiers in enamels for iron ware. Further investigations regarding the coloring power of cerium compds. in glazes of varying compn. would not only possibly prove to be of value to the ceram. indus., but would also help, if satisfactory results were obtained, to find an outlet for a portion of the large quantities of cerium compds. produced as residues of the rare earth industry. At present only a small fraction of the total cerium earths produced from monazite can be utilized. With regard to the utilization in the ceram. indus. of the other elements of the cerium group, there is little information published, but praseodymium, and neodymium phosphates have been employed to a limited extent in porcelain manuf. Tungsten and zirconium: Information regarding the use of these metals in glazes is even more difficult to find than is that concerning cerium. Good brown colors have been produced by means of phospho-tungstic acid, while similar results are obtained by the use of tungstic acid

in combination with iron and manganese. Results of doubtful value have been recorded with tungstic acid as an active agent for the development of under-glaze reds. Calcium tungstate, in combination with small quantities of a thorium or radium salt, imparts self-luminous properties to colored lead glazes, the luminosity being permanent when radium is used, but somewhat transient in the case of thorium. It is well known that zirconia has been found to be a good opacifying agent in enamels, but it does not appear to have been used in pottery glazes. O. P. R. O.

5. Gilding glazed clay vessels. P. P. BUDNIKOV. *Ber. Polyt. Iwanowo-Wosniessensk*, **6**, 211–20(1922).—B. has examined various methods of gilding glazed clay ware. A suitable gilding soln. is produced by pptg. Au from soln. in aqua regia by hydrous $FeSO_4$. The ppt. is ground with 8–10% of a flux consisting of 6 pts. of basic Bi nitrate and 0.5 pt. of anhyd. borax, mixed with oxidized turpentine and lavender oil, and applied to the wares. A bright Au film is produced after baking at 650–900°. Paler hues are obtained if about 30% by wt. of AgCl is mixed with the gold. "Sulfur balsam" may likewise be employed for gilding. 100 g. of dry French turpentine are mixed with 20 g. of S and 20 g. of Venetian turpentine and boiled gently on an oil bath. Acid must be distd. off at intervals, and it is best to carry out the distn. in a stream of CO_2, a long glass tube being employed as a reflux condenser. To 8–9 pts. of the balsam so prepd., a soln. of $AuCl_3$ contg. 1 pt. of Au, 4 pts. of concd. HCl, and 4 pts. of HNO_3, diluted with H_2O, is added, and the mixt. heated on an oil bath until the Au dissolves. H_2O is removed, and 7–8% of lavender oil and 12% of French turpentine are added, and the mixt. is heated until completely mixed. The resulting mass is dissolved in CS_2 and filtered. The CS_2 is evapd. off, and 5–8% of basic Bi nitrate added, and the resulting mass applied to the wares, which are then carefully baked at 450–600°. The reactions occurring have been investigated by studying the interaction of S and pinene. $C_{10}H_{16}S$ or $C_{10}H_{16}S_2$ is probably formed by reaction between pinene and S. With $AuCl_3$, the compd. $C_{10}H_{16}S.AuCl_3$ is probably formed, and by baking, this is probably decomposed into $C_{10}H_{16}Cl_2$, Au and SCl_2. Gold sulfide gives only a mat film, under the conditions of the expts. "Sulfur balsam" may be prepd. by the interaction, at room temp., of S_2Cl_2 and turpentine, the evolution of H_2S and HCl being prevented by cooling. Used in conjunction with $AuCl_3$ this gives even better films than the first-mentioned balsam. J. S. C. I.

PATENTS

6. Metallizing articles. QUINTIN MARINO. U. S. 1,452,281, Apr. 17. A process of metallizing articles composed essentially of non-conductive ceram. ware, which comprises applying to the surface of the article, while such surface is substantially free from glaze, a soln. of silver nitrate in an alcoholic solvent, allowing the alcohol to evap. applying to the surface a reducing agent contg. the formic acid radical, brushing the surface of the article with a metallic brush, applying to the surface of the article, a warm soln. containing silver cyanide, washing the article, and thereafter electro-depositing a metallic coating upon said article. Cf. *Ceram. Abs.*, **1** [8], 217(1922).

7. Gold coating mixture for glass or porcelain. JIRO ISHIKAWA. Japan. 40,632, Nov. 14, 1921. Ten g. of Au is dissolved in aqua regia, 38.5 g. of "balsam sulfide" is added and the mixt. evapd. to dryness on a sand bath. The residue is washed with H_2O, and mixed with Al, U, and Bi resinates and the whole is dissolved in a mixt. (*A*) of 200 g. of lavender oil, 100 g. rosemary oil, and 100 g. $PhNO_2$. "Balsam sulfide" is prepd. from 60 g. turpentine, 36 g. oil of turpentine, 16 g. flowers of S, 50 g. lavender oil, 10 g. $PhNO_2$ and 20 g. rosemary oil. The 3 resinates are prepd. from (1) K alum 50 g., resin soap 100, Al soap 10 and *A* 190; (2) U nitrate 50 g., resin soap 100 g., and *A* 150 g., (3) Bi subnitrate 2.3 g., resin 15.3 g. and lavender oil 32 g., resp. (*C. A.*)

Cement, Lime and Plaster

8. Alca cement. H. S. SPACKMAN. *Concrete* (Mill Section), **22,** 35–6(1923); cf. *Ceram. Abs.*, **1** [12], 337(1922).—Alca (= Al+Ca) cement has been manufd. in Europe since 1912, from bauxite and limestone. Its av. chem. compn. is CaO 35–45%, Al_2O_3 35–45%, Fe_2O_3 5–12%, SiO_2 5–12%. The cement is now made at 3 French works and at 1 Swiss works. Each works sells the cement under its own trade name, such as "Ciment Electrique," "Ciment Fondu," etc. Alca cement attains a very high early strength, and evolves considerable heat while setting, which favors its use in cold weather. Alca cement could be manufactured in the U. S. from native raw materials but the cost would be higher than for Port. cement. Economy in using the material tends to offset the high cost of production. J. C. W. (*C. A.*)

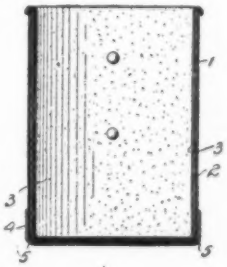
PATENT

9. Waterproof hardening agent of cement. KOMAKICHI KATO. Japan. 40,368, Oct. 19, 1921. The agent is a mixt. of soy-bean protein 100 g., NaOH 50 g., $Al_2(SO_4)_3$ 35 g., and AcONa 30 g. It is used by painting its aq. soln. with a brush on materials manufd. from cement or by mixing with cement. NaOH may be replaced with a mixt of Na_2CO_3 and $Ca(OH)_2$; $Al_2(SO_4)_3$ with alum and AcONa with soap or $Ca(AcO)_2$. (*C. A.*)

Enamel

PATENT

10. Enamel-ware protector. ALBERT E. PLOVER. U. S. 1,447,180, Mar. 6. The combination of a vessel enameled on the outside, and a protecting-ring of copper, arranged around the lower portion of the vessel, and having an annular integral portion extending inwardly under the bottom of the vessel.



Glass

11. Hydraulic mining of silica a marvel of mechanical ingenuity. ANON. *Glass Container*, **21,** 30(1923).—Described methods practiced at Clayton, Ia., where 5 men handled 7 carloads of glass sand per day, or almost 400 cu. yds. without touching the sand. Sand is 99½% pure. Illustrations. Deposits are enormous. One area of almost pure silica stretches for 10 miles at an elevation of 952 ft. A hydraulic stream, tumbler, separating vats and cars are all the equipment necessary. Fifty-five ton cars are loaded in 18 min. W. M. C.

12. Study of the return and breakage problem of milk bottles. ANON. *Glass Container*, **9,** 10 and 45(1923).—Part II. Checking up on mechanical operations in milk plants and careful supervision of delivery men result in reduced breakage and greater returns. With illustrations, Sheffield Farms, Inc., one of the largest N. Y. companies expends between $700,000 and $800,000 per annum for milk bottles. Breakage in washing averages between 1 and 2%. W. M. C.

13. Electric glass furnace. ANON. *Schnur. Rev. Glass Works*, **7** [74], 1563 (1923).—Not used because of cost, high local temp. and poor color of the glass due to carbon. The advantages are simpler installation, shorter melting period, cleaner furnace and a small furnace may be used. Power required is 2 kilowatt hour for 1 kg. of metal. R. J. M.

14. Health problems of industry. C. E. A. WINSLOW. *Glass Worker*, **42** [32],

11(1923).—A series of 8 special articles on this subject including efficiency, ventilation, lighting, dust, sanitation, fatigue, etc. R. J. M.

15. Fluorescence and coloration of glass produced by β-rays. J. R. CLARKE. *Philosophical Mag.* (London), **45,** 735–6(1923).—Glass tubing, after treatment with radium emanation until the color change is complete, was heated at different temp., and the rate of decolorization and the duration of fluorescence measured. The duration of fluorescence in min. ranges from 13 at 110° to 0.5 at 350° C. At the annealing temp., the change is practically instantaneous. It is probable that the fluorescence and decolorization are associated with changes in the state of mol. aggregation of the glass. When manganese is present in the glass the color after radiation is purple, whereas the normal color is brown. Cf. *Ceram. Abs.*, **1** [12], 328(1922). O. P. R. O.

16. Analysis of bubbles in glass. J. W. RYDE AND R. HUDDART. *Royal Phys. Soc. of London,* April 27(1923).—The analysis of bubbles in glass has been investigated by the research staff of the Gen. Elec. Co. of London: In order to distinguish bubbles generated by chem. action in glass from those introduced by mechanical processes spectroscopic tests are made for the presence of nitrogen. In order to liberate the gas from the bubbles a specimen of the glass was placed in one limb of a quartz U-tube and mercury in the other, and the glass was heated and then disintegrated by sudden cooling, the tube being plunged into cold water at the same time the mercury was thrown on to the glass. The method does not readily lend itself to quantitative applications, as the line intensities are much affected by the fact that the discharge takes place in a mixt. of gases. O. P. R. O.

17. Daughters of American Revolution plan to preserve ruins of old glass factory. ANON. *Glass Container,* 22, 38, 40(1923).—Old Pitkin Plant at Manchester, Conn., of historic interest to state and industry started in 1783. W. M. C.

PATENTS

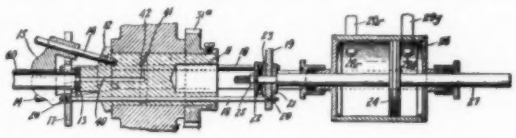
18. Ovenware and holder therefore. HARRY NEGBAUR. U. S. 1,450,330, Apr. 3. A baking dish made of transparent boro-silicate glass having a yellowish tinge and provided with mineral coloring material fused into the glass near one surface, whereby the dish is rendered translucent and colored.

19. Leer. LEWIS STEELMAN. U. S. reissue 15,603, May 15. An annealing leer for hot glass articles, comprising a heated fur. portion at the entry end of the leer and a tunnel portion having a gradually decreasing temp. extending therefrom to the exit end of the leer, the leer being arranged for continuous movement of the articles through the heated and tunnel portions to anneal the same in a gradually decreasing temp., the fur. portion comprising a muffle chamber with an open end leading into the tunnel extension flues surrounding the muffle portion of the leer chamber in which the articles to be annealed are placed, the side portions of which consist of a plurality of vertically extending flues, said flues being formed of interlocking tiles, an air and gas supply to the flue system, connections within the fur. structure for directing the flame and products therefrom substantially evenly on both sides of the muffle in the side flues, a conduit system beneath the heated muffle chamber in heating relation to its floor, said system receiving the products of combustion from the side flues and leading the said products of combustion in a horizontal longitudinal flow to stack connections, said stack connections being out of the path of travel of the articles being annealed and intermediate the length of the leer and adjacent the end of the heated portion, substantially as described.

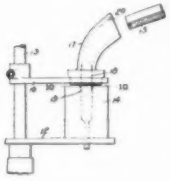
20. Glass tile for covering walls. MARCEL ANSPACH. U. S. 1,454,842, May 15. A method of prepg. glass tiles for wall coverings consisting in coating the back of said tiles with a paste contg. a clayey earth, oil, turpentine, a resinous varnish and a siccative, and baking at a moderate temp. the tiles thus coated.

21. Glass-drawing apparatus. WILLIAM GRAY. U. S. 1,449,038, Mar. 20. (See *Abs.*, **31**, p. 178).—An app. for drawing sheet glass comprising an endless member for carrying the sheet, an endless member of greater length associated therewith, teeth on said latter member to engage the margin of the sheet on one side, a shorter endless member with teeth to engage the margin of the sheet on the other side, and a sep. cooling bath for each of the last two endless members.

22. Glass-blowing machine. MINER P. WETMORE. U. S. 1,446,026, Feb. 20. The combination, with a revolving chuck having radially movable jaws of an operating connection from said jaws through the chuck spindle, rotatable therewith, a ball bearing on the rear of said connection, and means for producing movement of said ball bearing along the line of the axis of the chuck spindle.

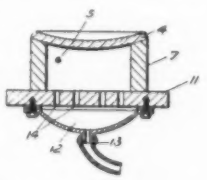


23. Apparatus for the manufacture of bifocal lens blanks. JOHN R. POWELL. U. S. 1,451,957, Apr. 17. In an app. for fusing bifocal lens blanks comprising a support for the major lens blank and a support for the minor lens pivotally mounted thereon having its free edge extended over the edge of the major lens support.

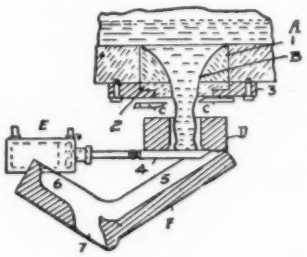


24. Process of and apparatus for feeding molten glass. WILLIAM A. LORENZ. U. S. reissue 15,600, May 15. In an app. for handling gathers of molten glass the combination with a conducting trough and a shaping mold of a curved inclosing funnel located between the delivery end of the trough and the mouth of the mold for conducting the gathers from the trough to the mold and shaping them while being so conducted.

25. Antæus glass. JOEL C. WELLS AND EDGAR D. TILLYER. U. S. 1,454,200, May 8. The process of producing protection lenses consisting in heating the lens uniformly and subsequently cooling one face of the lens while the other is in a plastic condition. The process of producing a curved protection lens consisting in surfacing the faces of the lens in flat form, subjecting the blanks after surfacing to sufficient heat to drop the lens to desired curve without impairment of the polished surfaces thereof, and suddenly chilling one face of the blank to produce a surface tension in the finished blank, increasing the resisting properties thereof.



26. Process and apparatus for feeding glass. WILLIAM J. MILLER. U. S. 1,451,707 Apr. 17. The method of feeding molten glass from a container provided with a discharge orifice through which the glass is caused to protrude which consists in accumulating the glass beneath the discharge orifice to form gathers, detaching said gathers from the glass protruding from said orifice, discharging said detached gathers, and reversing the gathers after they are discharged, for the purpose described.



27. Machine for making pressed glassware. THOMAS C. MOORSHEAD. U. S. 1,445,345, Feb. 13. A machine for making pressed glassware, comprising, a source of glass supply, a mold, a receiver adapted to gather a measured quantity of glass from said source means for dipping and for exhausting said receiver to gather the glass including main and auxiliary valves in series, said main valve being adapted to re-

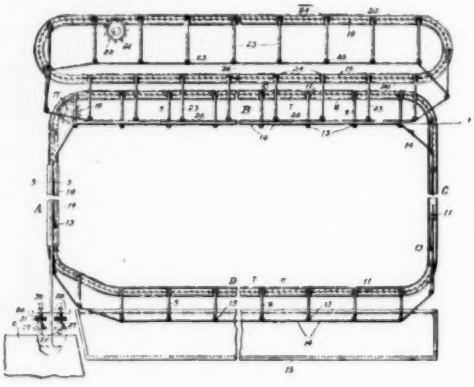
main open for the full dip of said receiver, and said auxiliary valve being adapted to close before said receiver rises, means for depositing the glass in said mold, and a former adapted to coöperate with said mold to press the glass to shape. In a machine for making glassware having glass molding means including a mold, mechanism for removing the formed article from the mold, comprising an ejector movable through the bottom of the mold, a coöperating retainer movable over the top of the mold, and means for removing the article from said ejector and said retainer.

28. Glass and process of making same. WILLIAM CHITTENDEN TAYLOR. U. S. 1,449,799, Mar. 27. The hereinbefore described method of overcoming the yellow tint imparted to acid boro-silicate glasses by iron oxide which consists in adding a salt of neodymium oxide to the batch from which such glass is melted.

29. Means for transferring glass to molds. LEONARD D. SOUBIER. U. S. 1,446,670, Feb. 27. A glass transfer device comprising a reciprocable carriage, a sectional transfer cup on said carriage and reciprocable therewith from a receiving position to a discharging position, the upper end of said cup being open to receive glass, and the section of the cup on the side towards the receiving position being slidable away from the other section, resilient means normally holding the sections together, and a stop for arresting the slidable section as it approaches discharge position and thereby opening the cup.

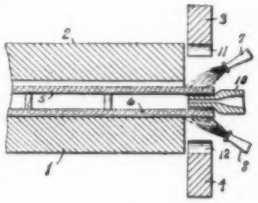
30. Means for transferring molten glass. JOHN MURL LENTS. U. S. 1,446,649, Feb. 27. In gob transferring mechanism, the combination of a gob transferring device rotatable about a horizontal axis and provided with a series of cups arranged at intervals around its periphery, means to rotate said device step by step and thereby bring said cups successively to a receiving position, said rotating means comprising a rock arm, means to rock said arm, a rotary member connected to rotate said transfer device, a connecting pin carried by said arm, automatic means to actuate the pin and connect said arm with the rotary member for rotation therewith while the arm moves in one direction and to disconnect said pin and permit said member to remain stationary during the return of said arm, a locking pin, and automatic means to move said locking pin into engagement with said rotary member and hold the latter in locked position while disconnected from the rock arm.

31. Glass-drawing apparatus. WILLIAM GRAY. U. S. 1,450,590, Apr. 3. In app. for drawing glass, the combination with a reservoir for molten glass, of drawing app. located thereover, and upright shafts located on opposite sides of the margins of the sheet being drawn and having outstanding fingers that engage said margins between the drawing app. and reservoir, to maintain a predetd. width to said sheet. In an app. for drawing sheet glass, the combination with a reservoir for the melted glass, of means for drawing a continuous sheet of glass vertically therefrom and then bending the sheet into the horizontal plane, comprising two endless series of articulated flat plates, the sheet being guided by one series of plates in its vertical run, and gripped between the two series in its horizontal run.

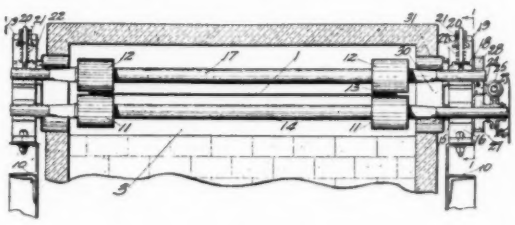


32. Process of making hollow panes of glass. IVAN M. KIRLIN. U. S. 1,448,351,

Mar. 13. The process of forming hollow panes of glass which consists in heating two similar sheets of glass between flat retaining plates, introducing a tube between the edges of the sheets at one point, heating the edges to fusing point and forcing them together and around the tube to hermetically seal the edges together and the tube in position and at the same time forcing air through the tube into the space between the sheets to hold them against the retaining plates, cooling the pane until no longer malleable, and then exhausting the air from its interior.

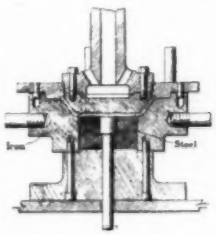


33. Leer conveyor for sheet glass. HORACE E. ALLEN. U. S. 1,450,571, Apr. 3. In a leer for continuous sheet glass, a series of idler rollers for supporting the glass sheet, and a series of means engaging the sheet between certain of the idler rollers at spaced intervals throughout the leer for advancing the sheet over the idler rollers. In a leer for continuous sheet glass, a series of idler rollers for supporting the glass sheet, a series of idler edge rollers, resting freely on the upper edge portions of the glass sheet to hold the sheet in rolling contact with the supporting rollers, and pairs of driving rolls engaging the edges only of the sheet for advancing the sheet through the leer.



34. Mold. ROWLAND D. SMITH. U. S. 1,449,789, Mar. 27. A part for molding glassware made of a steel containing from 10% to 15% chromium, and from ½% to 5% cobalt.

35. Mechanism for conveying hot glassware. MICHAEL J. OWENS. U. S. 1,455,966, May 22. In app. for transferring hot glassware, the combination of an inclined chute down which articles are carried by gravity, a horizontally traveling conveyor, a table beneath the chute onto which the articles are discharged from the chute, said table being rotatable about a vertical axis and in substantially the same horizontal plane as said conveyor, and means to guide articles from the table onto the conveyor, the point at which the articles are discharged onto the table being so arranged that the articles are carried on the table through the greater portion of a complete rotation and pass beneath the chute to the conveyor.



BOOK

36. Glass-making in England. HARRY J. POWELL. New York: Macmillan Co. 183 pp. $10.

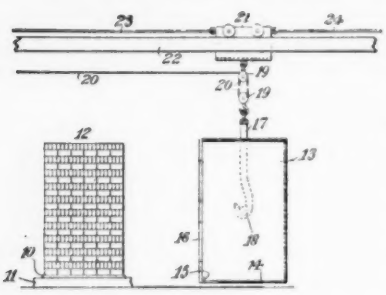
Heavy Clay Products

PATENTS

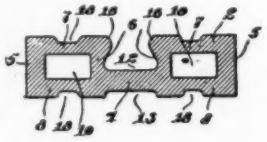
37. Apparatus for unloading kilns by hopper, lifting device, or the like. RAYMOND C. PENFIELD. U. S. 1,444,206, Feb. 6. App. of the kind described, comprising a brick carrying hopper, adapted to be positioned adjacent a stack of brick, rods adapted to slide on said hopper and extend forwardly thereof over the stack of brick, means on the outer ends of said rods to separate a predt. mass of brick from the stack and means to retract the rods and thereby slide the mass of brick thus sepd. into the hopper.

38. Apparatus for unloading kilns by conveyer belts. RAYMOND C. PENFIELD. U. S. 1,444,207, Feb. 6. Mechanical brick handling app. of the kind described comprising continuously moving brick engaging devices adapted to separate a plurality of brick in a stack, and to move the same from stacked position, comprising means to maintain the brick engaging devices in a substantially vertical line while entering the plane of the brick to be removed.

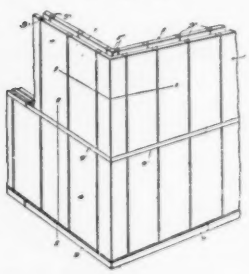
39. Brick-handling apparatus. HENRY O. POND and ARTHUR W. MELLEN, JR. U. S. 1,443,966, Feb. 6. In an app. for handling bricks and other articles piled in stacks, a receptacle constituting a carrier, having a front opening to receive and discharge the stack as a unit, releasable means for closing said front opening to confine the articles in the carrier during transportation, means associated with the bottom of the carrier to support the articles in the carrier but permitting the carrier to be loaded by horizontal movement over the stack, and a pivoted support for the carrier whereby the carrier may be swung to permit discharge of the articles downwardly by gravity through said front opening.



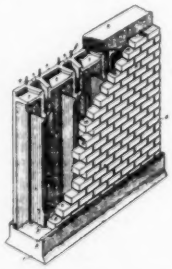
40. Brick. RICHARD BLAIR COOPER. U. S. 1,444,167, Feb. 6. A channel brick of the kind described, comprising a plurality of wall sections and a central area connecting the same together, mortar grooves in each wall section, and an overhanging finger grip on the inner edge of each wall section to constitute an eccentric handhold for the brick.



41. Building construction. ARTHUR W. KRUSEE. U. S. 1,447,868, Mar. 6. A building of the class described having its walls formed of a double row of slabs spaced apart to form an air space, each slab having recesses in its side edges, reinforcing means passing through the slabs and projecting into the recesses, metal strips bridging the space between the rows and having their ends located in the recesses, means for connecting the strips and the reinforcing members together in the recesses and a cement filling in said recesses enclosing the connected ends of the strips and reinforcing members.



42. Wall construction. EDWARD F. NEEDHAM and THOMAS H. NEEDHAM. U. S. 1,448,078, Mar. 13. A wall construction including adjacent wall slabs, the edges of said slabs being formed with ribs which extend at approx. right angles to the face of the slabs, the ribs of the adjacent edges of adjoining slabs fitting together and the upper ends of said adjacent ribs being spaced apart to form a recess between them, a transverse web connecting the upper ends of the edge ribs of the respective slabs, and an outer veneering for the wall.



43. Brick-surfacing machine. JACOB STOCKE, JR. U. S. 1,451,187, Mar. 10. A brick surfacing machine comprising a brick press having a ram, a table secured to said press, strips secured to said table, cutters secured in one of said strips and extending

therefrom, a movable end scoring blade adapted to be moved across the ends of a brick by the downward movement of the ram.

44. Brick kiln and method of setting and burning. WILLIAM J. SULLIVAN. U. S. 1,444,220, Feb. 6. That improvement in the art of burning brick which consists in building a kiln with relatively narrow arches and substantially twice the number heretofore employed, supplying heat to each arch in desired amount to bring the kiln to initial temp., then reducing the heat in each arch to prevent overburning of the arch brick and maintaining said reduced heat until the burning is completed.

45. Brick and tile machine. ROY H. MCELROY, JOSEPH D. CITE and ALBERT G. LANGENKAMP. U. S. 1,450,506, Mar. 17. In a machine for extruding plastic material a base casting consisting of a base member, an extruding casting member, a gear and shafting supporting member, and an outboard casting member all of said members integral with one another in a single casting, and reinforcing means consisting of dividing walls cast integral with said several members and the base member for maintaining the several parts together as a unit and reinforcing them, and an auger working in said extruding casting.

46. Brickmaking apparatus. HENRY W. B. GRAHAM. U. S. 1,452,152, Mar. 17. In app. of the class described, the combination with a brick machine having a filling station and a mold push out, of means for moving empty molds into position for feeding to said filling station, said means including a swingable receiver adapted to support a mold in position for engagement by said push-out. In a brick making machine, the combination of a pair of supports correlated to support molds and permit movement thereof from one support to the other, means for moving molds from one support to the other, one of said supports being pivoted whereby it may be moved to form a gap between them, and means for operating said pivoted support about its pivot to permit the delivery of a mold through the gap and the positioning of the mold on one of said supports.

Refractories

46a. Bauxite (France). ANON. *Chem. Trade Jour. and Chem. Eng.*, **72,** 668 (1923).—Fr. is now the predominant producer of bauxite in Europe and the principal producer of the world before the war, her output of 309,000 T being $^3/_5$ of the world's output; is now 2nd to the U. S., Ark. showing the most notable increase. O. P. R. O.

47. Keramite bricks. ANON. *Süddeutsche Tonind., Brit. Clayworker*, **32,** 17–18 (1923). A number of works have been engaged for some time in Switzerland, Sweden, Austria and Hungary producing Keramite brick. These brick are very hard and strong. The body consists of a well-ground clay and quartz sand, or some similar material. The clay serves as a bonding and sintering medium, while the sand serves to raise the melting point. Clay and sand are mixed together dry, whereupon 6 to 8% water is added to enable the mixture to be dry pressed. The brick are then pressed with 250 atmos. These brick are often fired at cone 13. In Hungary, Keramite brick have long been in use as a paving material and have proved exceptionally durable. They have a mean compression strength of 64,000 lbs. per sq. in. The paving blocks are usually made of the following dimensions: $11^1/_2$″ by 4″ by $2^1/_2$″ to 3″. They consist of 54 SiO_2, 14 Al_2O_3, 8 Fe_2O_3, 16 CaO and 4 to 5 MgO. Owing to the high CaO content the Budapest brick are yellowish green in color. H. G. S.

48. Rammed linings replace bricks. ANON. *Brit. Clayworker*, **37,** 17(1923).—Owing to the high price of fire brick, the use of rammed lining of ganister or silica rock is becoming popular. It is true that bricks cannot be dispensed with in some types of furnaces, but the number which might use rammed linings is very large. Steel furnaces, cupolas used in foundries, calcining furnaces, lime kilns, vertical cement kilns, and many

reverberatory may use rammed linings. About 20,000 tons of ganister are used each month in Germany for this purpose. The material employed is an almost pure silica rock which is crushed to powder, mixed with about 2% of CaO, and then ground into a stiff paste with water. The furnace is fitted with adjustable lining rings or with blocks, which are placed so as to act as one side of a mold, while the fur. wall acts as the other side. The space between them is filled with the paste which is then rammed or tamped into position. When the lining is completed, the rings or blocks are removed, and the furnace is "dried out" in the usual manner. No fire brick or blocks are used at all, and the experience of 4 yrs. of this practice has shown it to be highly economical. The results obtained have proved so good that the near future may see the discarding of most of the bricks and blocks now used. Patching is done after every heat, and a relining is not necessary within 2 yrs. H. G. S.

49. Carbonized brick. W. SMITH. *Brit. Clayworker*, **32**, 17(1923).—Carbonized brick are produced by treating clay with carbon-charged gases, being different from brick made with a mixture of C and clay. Carbonized clay falls into two groups, i. e., black and white, the former providing a material adapted for heat resistance in reducing atmos., while the latter should be used in furnaces where air is freely admitted. As a heat conductor, the clay should be used in the black condition, as a non-conductor, in the white. Carbonized clay is recommended for filter beds, and the production of high-class acid-resisting ware, while its hardness is just short of SiC. The carbonized brick conducts with twice the efficiency of the standard fire brick. Attention is drawn to the possibility of liberating Fe_2O_3 from red clays by this process. Alkalies may also be liberated from clay by this process. See *Ceram. Abs.*, **2** [5], 101(1923). H. G. S.

PATENTS

50. Manufacture of self-hardening refractory articles. WILLIAM A. FRANCE. U. S. 1,451,540, Apr. 10. The method of manufacturing refractory articles, such as furnace-lining bricks, which consists in mixing magnesite with other elements including magnesium chloride in a molten condition, forming the same, and finishing the resultant by subjecting it to the drying action of air and without burning.

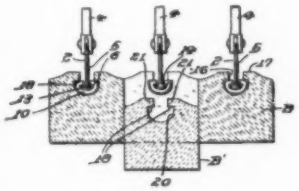
51. Refractory article and method of making the same. FRANK B. DANEHOWER. U. S. 1,450,140, Mar. 27. A refractory article of manuf. being a baked product and comprising a comminuted refractory body and the residue of decomposition of synthetic phenol resin which acts as a bond for the comminuted refractory body.

52. Method of molding brick shapes. CHARLES L. NORTON. U. S. 1,444,519, Feb. 6. In the designated method of molding brick-shapes of granular non-plastic material, accumulating a mold charge at a height above a mold, and simultaneously depriving said charge substantially in its entirety of both vertical and lateral support.

53. Furnace. PERRY R. CASSIDY. U. S. 1,448,194. A stationary substantially horizontal fur. or oven comprising a stable continuous curved inner wall of refractory material under compression, and an outer metal shell surrounding the same for maintaining the inner wall under compression and resisting stresses due to expansion thereof the metal shell being provided with a slip joint and means for maintaining the same under constant tension.

54. Fire arch for furnaces. ERNST EMIL FROZETH and TERRY BLIXT. U. S. 1,452,295, Mar. 17. A fire arch of the class described consisting of a number of suspension blocks, the same being widest at their lower ends and arranged so as to form with their lower ends the entire under side of the arch, means for hanging the suspension blocks in a boiler or furnace, and a number of downwardly tapered wedge blocks adapted to be inserted and substantially fill the space in between the suspension blocks above said lower ends.

55. Suspended furnace roof. WILLIAM C. STRIPE. U. S. 1,448,879, Mar. 20. In a structure of the class described, the combination of a hanger beam having an enlarged lower portion, means slidable on said beam and adapted to engage said portion to receive support therefrom and a brick having an under-cut slot adapted to receive said slidable means when moved into said slot from either end thereof, the overhanging portions of the brick adjacent the slot operating to retain said means from vertical displacement therein.



56. Laminated superrefractory article. MILTON F. BEECHER and MACDONALD C. BOOZE. U. S. 1,448,684, Mar. 20. A laminated refractory article having a facing of bonded refractory material, a reinforcing backing layer of ceram. material which is reactive with an ingredient of the facing, and a neutral intermediate layer intimately joined to and separating the facing and backing layers.

Terra Cotta

57. The effect of nickel salts on the color. G. M. TUCKER. *N. J. Ceramist*, **1** [4], 268(1921).—Four calcines were prepd. as follows:

A	1 Part Salt 5 Parts Flint	B	1 Part Salt 2½ Parts Zinc 2½ Parts Flint
C	1 Part Salt 2½ Parts Whiting 2½ Parts Flint	D	1 Part Salt 2½ Parts Calcined Magnesite 2½ Parts Flint

In each of these calcines the following were substituted successively for the "salt:"

1—Nickel	7—Nickel formate
2—Basic nickel carbonate	8—Nickel borate
3—Nickelic hydrate	9—Nickel sulphate
4—Nickel hydrate	10—Nickel silicate
5—Nickel nitrate	11—Nickel oxide green
6—Nickel chloride	12—Nickel oxide black

These calcines were ground dry and burned to cone 5½ in a commercial terra cotta kiln, reground and washed. 5% of each calcine was substituted successively in each of the two glazes. One glaze contd. cornwall stone, high content of CaO and no zinc. The other glaze was of the bristol type. Colors obtained varied throughout a considerable range which is given in detail. It appears that magnesium oxide in calcine D exerted greater influence on color than the nickel itself when used in the bristol glaze.

C. W. P.

58. An unusual experience with flat roofing tiles. ANON. *Brit. Clayworker*, **32**, 18(1923).—Tile fired in Hoffman kilns had the ordinary "porous" body, yet both surfaces had cracks with a distinctly vitrified, glassy appearance. The following explanation was given. During firing, certain physical and pyrochemical changes occur in the body of the tile. Firing to maturity produces, in the main, a softening of the mol. composing the mass. In this condition, which precedes actual melting, the adhesive force acting between the mol. is practically suspended. If, at this point, a cold current of air comes into contact with a portion of the tile causing local shrinkage, a crack is

the result; but since the individual mol. in this condition possesses no cohesion, the resulting fracture appears smooth. The conclusion to be drawn from these considerations is that any abrupt cooling of the tiles, while at the high temp. must be avoided.

H. G. S.

59. Slip glazed ware. ANT. HÜTTL. *Keram. Rundschau*, **31**, 89(1923).—Brown ware is made in many portions of Germany. The appearance of this ware varies in different localities depending upon the nature of raw materials necessary to make this glaze. Many clays can be used in their natural state to produce glazes if fired sufficiently high but fluxes are usually added to reduce their maturing temp. The analyses of a slip glaze is as follows: SiO_2 = 59.10%, Al_2O_3 = 11.72, Fe_2O_3 = 4.16%, CaO = 7.46%, MgO = 1.84%, K_2O = 4.83%, CO_2 = 6.09% and loss on ignit. = 4.80% which corresponds to the following formula:

$$10.04\ SiO_2,\ 0.136\ Al_2O_3 \begin{cases} 0.029\ FeO \\ 0.095\ CaO \\ 0.049\ MgO \\ 0.051\ K_2O \end{cases}$$

Slip glazes are cheaper than artificial glazes. The Na in wood ashes is often dissolved in water and this soln. is mixed with the glaze having the proper consistency. The Na thus introduced lowers the maturing temp. and improves the quality of the glaze.

H. G. S.

PATENTS

60. Porcelain having the appearance of granite. TOMOTARO KAWAMOTO AND GOSUKE KATO. Japan. 40,582, Nov. 29, 1921. A mixt. of feldspar 50, silica 20, marble 20, clay 10, and limestone 5 parts is crushed, passed through a sieve having 15–20 mesh per 3 cm. and mixed with coarse granules of granite. The mixt. is molded under 40 lb. pressure and heated at 1300° for 10 hrs. (*C. A.*)

61. Purification of gypsum. SHOTARO FUKATA. Japan. 40,417, Oct. 25, 1921. Impure waste or pptd. gypsum (1 part) is burned at 128–190° until the H_2O content becomes less than half a mol. for 1 mol. of gypsum and then powdered. About $^1/_{10}$ part of H_2SO_4 (65° Bé.) is dild. with 20–30 parts of H_2O and heated at about 100°; the powdered gypsum is gradually added and agitated. Monoclinic crystals gradually develop. When the crystn. is completed, the product is sepd. from the acid, washed with H_2O and dried below 60°. (*C. A.*)

Whiteware

62. Some notes on materials and processes in electrical porcelain manufacture. T. A. KLINEFELTER. *N. J. Ceramist*, **1** [4], (1921).—A somewhat detailed discussion of the processes employed in the manufacture of both high and low tension elec. porcelain together with some remarks upon the phys. properties of the burned wares. C. W. P.

PATENTS

63. Tool for decorating crockery. HYMAN KISSNER and DAVID BLUM. U. S. 1,445,627, Feb. 20. A tool for decorating crockery comprising a wheel of resilient material having a bevel peripheral face, a separate design strip secured on the bevel face, and a suitable mounting for the wheel for operating the same.

64. Insulator. LOUIS STEINBERGER. U. S. 1,446,135, Feb. 20. An insulator and supporting pin therefor, said insulator having a bore extending thereinto from the lower side or end thereof, the pin fitting and extending into end bore, said bore and pin having their adjacent surfaces smooth and free from protuberances or projection throughout the upper and greater

portion of their extent, mutually engaging securing means between the insulator and the supporting pin, said securing means located only at the lower end or side of the insulator and remote from the apex of the pin, and a seat for the line wire on the upper end or side of the insulator remote from said securing means.

Equipment and Apparatus

65. Heating electric steel furnaces. M. GILLOT AND V. GUILLERMIN. *Rev. ind. minerale*, **1**, 249–57(1921); *Rev. metal.*, **18**, 590.—Furnaces give the best results with a surface of bath not over 1.20 m.^{2} per electrode for small furnaces and 1.80 m.^{2} for 15-ton furnaces. The output per electrode should be not over 3–4 amp. per cm.^{2} for carbon and 12 for graphite. Various little known methods are described for economizing heat by prevention of leakage, better conduction and convection within the furnace, and construction of electrodes. C. C. D. (*C. A.*)

66. Some developments in gas producers. T. R. WOLLASTON. *Iron Coal Trades Rev.*, **106**, 196(1923).—Results obtained from gas producers of the recovery and non-recovery type are compared with those from an improved plant. Diagrams indicate the sources of loss and inefficiency as compared with the new plant; these are expressed in B. t. u. and money value. The R-G plant which furnished the data has a producer 9 ft. in diam. of 1300 lb. capacity per hr. The fuel is introduced through a retort in contact with hot exit gases and is thus partly coked, while the gases are enriched. The steam for the process is raised in an annular boiler around the unlined producer body. Blast satn. and superheat are derived from a central cone-shaped boiler within the producer which acts as a flash boiler. The precoking leads to a wide extension of the range of common fuels available, to practical elimination of clinkering, to great ease and economy of working, and to the production of a gas of unusually high value, CO_2 10.6%, CO 18.8, H_2 24.4, CH_4 3.9, total combustible 45.1, heating value range 164.5 to 182.5 B. t. u. J. L. W. (*C. A.*)

67. Calite, a new alloy resistant to high temperatures. J. GAILLARD. *Usine*, June 17, **1922**; *Rev. universelle mines*, **16**, 317–8(1923).—Calite is an Al-Ni-Fe alloy made in a basic Heroult elec. furnace by fusing and decarbonizing scrap steel, removing the dross, adding Ni, reducing the melt and adding approx. 25% of scrap calite by wt. to the charge. When homogeneous, the metal is run into a previously heated receptacle contg. the requisite amt. of Al, and from this to the molds. It is hard, and either hot or cold is highly resistant to shock. It is not oxidized below 1300°, can be used indefinitely at 1200°, is easily sol. in 25% H_2SO_4, is insol. in HNO_3, is very slowly dissolved by HCl, is not attacked by fused carbonates, chlorides, nitrates, cyanides, Pb, Zn, Sn, S and S vapor, but is attacked by cryolites, borates and silicates. It melts at 1525°, softens at 1370°, can be worked at 1200–1300°, has d. 7.07, Brinnel hardness after annealing 286, hardness by the scleroscope after annealing 40, thermal cond. 25% that of Fe, tensile strength 25.8 kg. per mm.^{2} The % compn. is not given. C. C. D. (*C. A.*)

68. Relation between current, voltage, and the length of carbon arcs. A. E. R. WESTMAN. *Trans. Am. Electrochem. Soc.*, **43**, preprint (May, 1923). C. H. E. (*C. A.*)

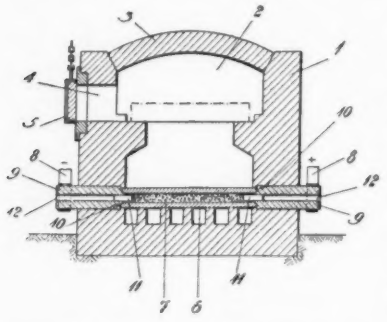
PATENTS

69. Rapid decorating firing furnace or kiln. RANSOM W. DAVENPORT. U. S. 1,451,815, Mar. 17. In a furnace for heat treating bodies, a tubular member for contg. bodies, means for heating the central portion of the wall of the tubular member, a plunger for moving the bodies through the tubular member, and means for directing a chem. reagent through the tubular member.

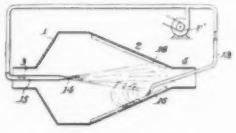
70. Sifting testing machine. WILLARD J. BELL. U. S. 1,450,166, Mar. 3. In a sifting testing machine, the combination of spaced shaking plates adapted to receive

testing sieves therebetween, a series of connected resilient sieve-engaging arms interposed between said sieves and one of said plates, and a handle on one of said arms adapted to permit such arm to be swung away from said sieves to allow of removal thereof.

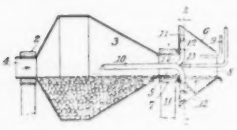
71. Method and device for the heating of material in electric furnaces. EUGEN ASSAR ALEXIS GRÖNWALL. U. S. 1,450,543, Apr. 3. An elec. fur. comprising refractory pipes, auxiliary resistances of carboniferous material disposed in said pipes, a pair of hollow electrodes in contact with said pipes, and an auxiliary electrode in each of said hollow electrodes and extending into said pipes for ensuring a satisfactory transmission of current from the electrode to said auxiliary resistances.



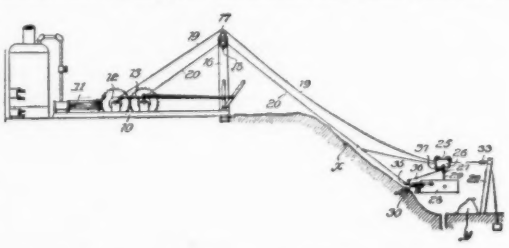
72. Oversize return for mills. HARRY W. HARDINGE. U. S. 1,450,290, Apr. 3. A grinding mill comprising in combination, a rotatable grinding drum having a substantially unobstructed overflow conical outlet portion for the classification of material according to size, a classifier into which said drum discharges, and means for automatically returning oversize material from said classifier to said drum through the end of said conical outlet portion.



73. Apparatus for entraining and removing fines from conical mills. HARRY W. HARDINGE. U. S. 1,450,289, Apr. 3. The combination with a conical grinding mill comprising a rotatable drum having a conical outlet portion for automatically classifying material according to size, provided with an outlet opening for discharging the material when ground, of a jet which discharges into said conical outlet portion adjacent the base thereof and directed toward said outlet opening, said jet and conical outlet portion cooperating to form an ejector and means for supplying elastic motive fluid to said jet under pressure.



74. Excavating machine. MILTON S. LONGNAKER. U. S. reissue 15,571, Apr. 3. In app. of the class described, an inclined cable or support, means for slackening and drawing the cable taut to alter its degree of inclination, a movable carriage arranged to travel on the inclined cable and movable thereon in one direction by gravity, a pivotally hung load conveying device suspended from said carriage for free pivotal movement, and an operating cable connected to said conveying device and arranged to haul the same in the opposite direction.



75. Press for forming briquettes. JEAN RÉOL. U. S. 1,454,906, May 15. A double compression press comprising a fixed support, a rotary mold table, an operating lever pivoted on said support, a compression plunger pivotally connected to the operating lever, an ejector plunger also pivotally connected to said lever, a second compression

plunger arranged to move in the opposite direction to the first, a rod and lever connecting the second compression plunger to the operating lever, a hydraulic cylinder, a piston therein, a block carried by said piston, the said connecting lever being arranged on said block, and a rotary cam arranged to impart max. speed to the table during the periods between compression and to hold the table against movement during the periods of compression.

76. Separator. THOMAS J. STURTEVANT. U. S. 1,454,140, May 8. A separator for grading materials, comprising, in combination, a screen, a support therefor beneath the screen, and means for vibrating said support and screen including an eccentric mechanism connected to said support and having minute eccentricity and rotatable at high speed, said screen being unattached to said support, that it may float and tremble on the support with independent vibrations.

77. Shale planer. JOSEPH M. POWELL. U. S. 1,454,519, May 8. A shale planer, comprising a pivot car, a track on which said pivot car is mounted, means for feeding said pivot car forward along said track, a frame pivotally mounted on said pivot car, means in addition to said pivot car for supporting said frame and permitting it to swing about its pivotal mounting on the pivot car, and a perpendicularly extending shale-cutting mechanism carried by said frame.

78. Furnace gas producer. CLIFFORD E. WENTZEL. U. S. 1,455,181, May 15. The combination with a fur. comprising a combustion chamber and an ash pit, of a bed plate interposed between said ash pit and said combustion chamber and having an opening therein, a structure movable into and out of a position to close said opening and adapted to support fuel and ashes in said combustion chamber, and a tuyere supported by said bed plate, extending across said opening and having outlets arranged to discharge into the fuel and ashes on said movable structure.

Chemistry and Physics

79. Physics in the ceramic industries. J. W. MELLOR. *Inst. Physics*, May 9 1923.—The specific applications of sound, light, heat, electricity and magnetism, and mechanical science in the manuf. of pottery and glassware, demonstrating that physical principles can render great service to the ceramic industries. Fire brick are actually rejected when they do not give a sonorous ring; yet silica brick, made with calcined quartz, are not inferior in spite of their leaden ring. Light, copper-blue glazes can be matched in artificial light, but cobalt and chrome colors cannot. If the absorption spectra of metallic oxides had been better known, certain troubles would not have arisen with cobalt-blue lamp bulbs during the war; the reddish glow of these lamps can be cured by the addition of chromic oxide, but not by copper oxide. The changes of quartz into α and β tridymite and cristobalite observed by the detn. of the refractive indices, are not approved by some silica brick-makers. Others look to X-ray examn. for further help. Iron particles are removed from clay by magnetic separators, but the problem of the sepn. of cupriferous pyrites by electromagnetic or electrostatic methods remains unsolved. The processes of firing ordinary bricks are efficient; of the fuel spent in firing biscuit-ware only 2% is utilized and improved fur. flues and screens, useful in the early stages of the operations, might be disastrous in the later stages. During the first stages the loss of water and the contraction proceed at the same rate. Later, the contraction ceases, though the loss of water might continue, and contraction strains should be studied apart from thermal strains. The manufacturer should be asked whether special shapes leave a good safety margin in manuf. and use. Circular plaques crack in radial lines, oval plaques in directions toward either focus. When clay passes through a long-nosed pug-mill, a slab cut in the direction of motion has a greater contraction than when taken at right angles thereto. M. had at first thought the wetter

clay accumulated near the axis; but the flat particles seemed to travel broadside, like a coin sinking face downward in water. A bat of clay distorted during drying can be straightened by damping and drying it under pressure; but during the subsequent firing the particles contract again. Elec. fur., invaluable for high-temp. work, are unsatisfactory for pottery firing. Gas and coal firing acts mainly by convection currents, elec. heating by radiation; large electrically-heated chambers might be provided with mechanisms to ensure better gas circulation and convective heating. The many French measurements of the expansion coeff. of glazes and bodies have so far proved of no practical value, not because they are in themselves useless, but because the problems involved are very complex. O. P. R. O.

80. Studies of the clays. II. Centesimal and rational analyses, use of microscope. O. BOUDOUARD AND J. LEFRANC. *Bull. soc. chim.*, **31**, 1145–52(1922); cf. *Ceram. Abs.*, **2** [5], 110(1923).—The rational analysis of Vogt depends on the facts (1) that clay, kaolin and mica are dissolved by boiling H_2SO_4, but quartz and feldspar are almost unattacked. (2) Boiling NaOH soln. (sp. gr. 1.8) attacks biotite but not muscovite. A centesimal analysis is made and an analysis of the portion extd. by boiling H_2SO_4. From these figures the kaolinite, muscovite, sand, H_2O and undetd. constituents are deduced. It is shown that the results of the rational analysis may be deduced from the centesimal analysis by ordinary methods of chem. calcn. Microscopic examn. greatly aids in the lithologic interpretation of the centesimal analysis. L. W. R. (*C. A.*)

81. The dissociation of calcium sulfate at higher temperatures. P. P. BUDNIKOV AND J. K. SYRKIN. *Chem.-Ztg.*, **47**, 22(1923).—Dissociation begins in the neighborhood of 800°. At 1375° the dissociation pressure apparently reaches 1 atm.; melting occurs simultaneously. The decompn. products are CaO and SO_3. The results of the analysis upon the former and the differences in weight, upon heating, are given. Heating to 1000° as in the formation of *Keene's cement* produces only a small quantity (about 3.2%) of CaO. H. C. P. (*C. A.*)

82. A new viscosimeter. P. LECOMPTE DU NOÜY. *J. Gen. Physiol.*, **5**, 429–40 (1923).—This app. utilizes the principle of coaxial cylinders. An outer cylinder contg. the liquid rotates around a plunger immersed in the liquid. There is a direct proportionality between the torque due to the friction exerted by the liquid on the plunger when the outer cylinder is rotating and the rate of rotation. The readings are, therefore, proportional to the rate. The app. is particularly adapted to the measurement of colloidal and physiol. solns. Less than 1 cc. of liquid is required for a measurement. Other advantages are: Rapidity of operation (30 sec. to 1 min. for a reading), accurate temp. control, large range and ease of changing the range, great sensitivity. It can be used as a recording viscosimeter. C. H. R. (*C. A.*)

83. The development of mineralogical methods. T. L. WALKER. *Am. Mineral.*, **8**, 41–6(1923).—Presented chronologically, the methods which have been developed for mineralogical research and description are: the Wernerian (use of the more obvious phys. properties); geometrical (crystal form) ; chem.; petrographic (microscopic study of transparent minerals); synthetic (artificial production of minerals); mineralographic (microscopic study of opaque minerals); and the method of Friedel and Laue (X-ray detn. of cryst. structure). E. F. H. (*C. A.*)

PATENTS

84. Method of recovering vanadium from its ores. PHILIP ALEANDER MACKAY. U. S. 1,450,507, Apr. 3. A method of recovering vanadium pentoxide from the other oxides combined with it in vanadium ores, particularly lead oxide, by subjecting the ore to the action of oleum at a suitable temp., reducing the vanadium pentoxide to vanadium tetroxide, in order to obtain vanadyl sulphate, and subsequently diluting the soln. with water to ppt. the insol. constituents of the ore and to leave the vanadium in soln.

85. Reduction of oxides of metals of the chromium group. RICHARD EDGAR PEARSON AND EUSTACE NEVILLE CRAIG. U. S. 1,448,036, Mar. 13. A process for the reduction to lower oxide of the tri-oxide of a "chromium-group" metal which consists in immersing a cathode in an intimate pasty mixt. of the powdered oxide and an electrolyte in which it is insol. and passing a direct current through the mixture.

86. Process for the manufacture of borax and boric acid. ANDREW KELLY. U. S. 1,450,975, Apr. 10. A process for the manuf. of borax characterized by treating sodium pentaborate by adding thereto a sodium salt and ammonia.

87. Process of producing zirconium dioxide. OTTO RUFF. U. S. 1,454,564, May 8. A process of treating zirconium ores, which comprises strongly heating the ore with a carbonate of an alkali metal, the mixture contg. for each mol. equiv. of zirconium oxide about .75 to 2 mol. equiv. of said carbonate, and for each mol. equiv. of alumina and silica, about 1 to 1.5 mol. equiv. of said carbonate, and thereafter dissolving the water insol. zirconium compds. in an acid.

88. Method of separating zircon from undesired substances. LOUIS E. BARTON AND CHARLES J. KINZIE. U. S. 1,451,004, Apr. 10. The method of treating ores contg. zircon and therewith entangled undesired substances which comprises commingling therewith an alkali metal bisulphate, heating the charge, livixiating the resulting product, and sepg. its liquids from its zircon residuum.

89. Method for making plastic gypsum. ROBERT E. HAIRE. U. S. 1,457,161, May 29. The herein described method of making plastic gypsum, consisting in passing calcined gypsum through a tube mill with substantial exclusion of air in circulation through said mill to thereby prevent loss of the water content during the grinding, the material being allowed to discharge at the periphery of the mill when the desired degree of plasticity is reached.

90. Process of producing magnesium nitrate. VICTOR MORITZ GOLDSCHMIDT. U. S. 1,454,583, May 8. A process of producing magnesium nitrate which comprises treating olivine and serpentine with nitric acid of 25–40% at a temp. of 50–90°C, whereby the silicic acid is pptd. in an easily filterable state.

91. Process of making sodium-silico fluoride. HENRY HOWARD. U. S. 1,456,594, May 29. Process of making alkali silico fluorides which comprises acidulating phosphate rock with sulphuric acid, sepg. the resulting solution from insol. material, adding to the soln. an alkali in quantity insufficient to convert the phosphoric acid in the soln. to the mono alkali salt, and recovering the resulting precipitate of alkali silico fluoride.

General

92. New Jersey's part in the ceramic history of America. LEROY H. MINTON. *The Ceramist*, **2** [4], (1922–23).—A sketch of the historical development of the ceramic industry in New Jersey, together with statistical information regarding the production of various kinds of wares. C. W. PARMELEE

93. The hardening and the speed of solution of calcined gypsum. P. P. BUDNIKOV AND J. K. SYRKIN. *Z. anorg. allgem. Chem.*, **125**, 257–68(1922).—A study of (1) the rate of soln. of gypsum calcined at temps. from 100 to 800°, (2) the role of the insol. form in retarding the hardening and (3) the peculiarities of the crystn. process. All samples were heated from 5 to 8 hrs., cooled rapidly, ground fine and 2 g. digested in a const. vol. of H_2O at 20°. A definite procedure was used since the soly. may vary up to 20%, depending upon the size of particle (cf. *Z. physikal. Chem.* **37**, 385). Gypsum calcined at 115–25° was composed chiefly of $CaSO_4.{}^1/_2H_2O$ and rapidly formed a strongly supersatd. soln., based on $CaSO_4.2H_2O$. The soly. then decreased to a soln. only slightly supersatd. The existence of a soln. satd. with respect to $CaSO_4.{}^1/_2H_2O$ could not be verified, indicating that the rate of crystn. of $CaSO_4.2H_2O$ was approx. the same as

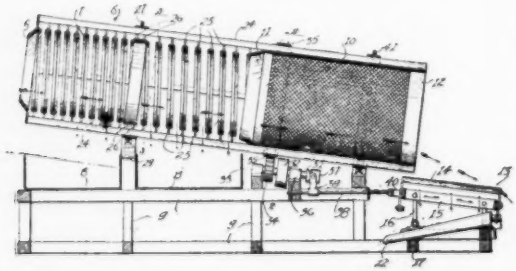
the rate of soln. of the hemihydrate, though the rate of crystn. exceeded that of the soln. of the hemihydrate, preventing the existence of a hemihydrate soln. Calcined at higher temps., soln. took place rapidly and then ceased, with no max. supersatn. or subsequent decrease in soly. as with calcination at 120°. A great difference was found between the products calcined at 400° and 500°. With the 400° product, supersatn. and hardening still took place, but with the 500° product, a normal satd. $CaSO_4$. $2H_2O$ soln. existed after 8 hrs. (cf. Glasenapp, *Studien über Stuckgips, totgebrannten und Estrichgips*, Riga, **1908**). If hardening were a result solely of the pptn. of dihydrate, dead-burnt gypsum would not harden, but since it does set slowly, a transformation of the insol. form of $CaSO_4$ to the sol. form must occur. Though boiling ordinarily reduces the ability of gypsum to form supersatd. solns., it had the opposite effect on that calcined above 400°, the rate of transformation to sol. $CaSO_4$ being accelerated. Calcined from 500 to 800°, gypsum showed a much retarded rate of soln. At first it dissolved rapidly until all the sol. form of anhydrous $CaSO_4$ was in soln., after which the insol. form of anhydrous sulfate (the chief constituent) passed into soln. extremely slowly only after transformation to the sol. form. Dead-burnt gypsum contains considerable amts. of sol. anhydrous sulfate and its inability to harden is due to a phys. retardation by the insol. form. A sharp transition temp. of calcination from hardening to non-hardening properties could not be detd., though with rise in temp. of calcination the soly. decreased progressively and hardening was retarded; this was probably due to increasing proportions of the insol. form of anhydrous $CaSO_4$. See also *Ceram. Abs.*, **2** [6], 121(1923). C. C. D. (*C. A.*)

PATENTS

94. Treatment of clay. WILLIAM FELDENHEIMER AND WALTER WILLIAM PLOWMAN. U. S. 1,447,973, Mar. 20. In the treatment of clay, the step consisting in effecting deflocculation of the clay by admixing the latter with an aqueous soln. of a resin in an alk. solvent therefor. See *Ceram. Abs.*, **2** [6], 138(1923).

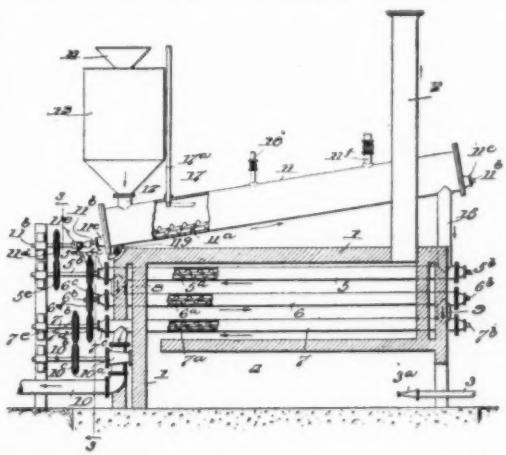
95. Composition of matter for cleaning crystal and glassware. JULIA ETTA GROVER U. S. 1,449,281, Mar. 13. A compn. of matter for cleaning glass and chinaware, formed by mixing and boiling substantially sal soda, borax, sulphur, oil of citronella, alum, chlorinated lime, glycerine and water.

96. Apparatus and method for sampling ores. FRED MASON MARTIN. U. S. 1,488,758. In the art of obtaining samples of a sticky material, the method which consists in causing a mass of the material to move continuously in a compact stream of substantially equal cross-sectional area thereby to insure the passage per unit of time of equal amounts of the material, causing said stream to fall freely in air disintegrating said compact stream while falling freely and unrestrained, periodically removing from equally spaced apart portions of said uniform disintegrated stream, a relatively small amt. of the material and assembling all of said small amt. removed from the stream to form a fair sample of the whole mass.



97. Grading apparatus. JAY W. ELLENWOOD. U. S. 1,450,145, Mar. 27. In an app. of the character described, the combination of a revolving inclined cylinder having an open receiving and discharging end, supporting means for said cylinder, means for rotating said cylinder, a coil mounted within said cylinder, said coil being

formed of material having a triangular cross-section with one of the apexes directed toward the interior of said coil, the convolution of said coil increasing in spaced relation one to the other from the receiving end toward the discharging end, a screen adapted to receive material from said coil and discharge said material at its opposite end, a riddle comprising a reciprocating frame, a series of spaced parallel ribs mounted thereon, a central bar rigidly supported on said frame, the other of said bars being pivotally attached to said frame, means for adjusting said bars with respect to each other and means for reciprocating said frame simultaneously with the rotation of said cylinder and coil.



98. Apparatus for the combined solvent and destructive distillation treatment of shale. DAVID T. DAY. U. S. 1,447,296, Mar. 6. App. for extracting hydrocarbon oil material from oil bearing shales which app. comprises retort means for distilling shale, a treatment chamber capable of holding a bath of oil and having an opening for the introduction of fresh shale, a shale discharge opening for the discharge of treated shale, a discharge opening for the aeriform material produced, and an opening for the discharge of extracted oil material, means for removing shale from said chamber and passing it to said shale discharge opening, and a pipe directly connecting said chamber and said retort for conducting directly into said chamber material distilled from shale in said retort.

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Committee on Standards (*a*) Tests (*b*) Products	W. J. Stephani C. F. Binns	(*a*) E. P. Poste	Tests: A. E. Williams; L. R. Milford. Refractories: D. E. Sharp; C. E. Fulton; W. F. Brown; A. S. Zopfi; G. Aurien; C. O. Grafton	P. H. Bates W. G. Worcester S. Geijsbeek W. P. Blair	R. F. Ferguson M. C. Booze R. M. Howe	(*a*) C. W. Hill D. F. Albery (*b*) J. L. Carruthers	(*a*) G. Sladek A. V. Bleininger (*b*) A. S. Watts[1] J. P. Rodgers Chas. Golding E. W. Turner Jno. Manor C. N. Franzheim T. A. Kleinfelter C. C. Treischel
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Com. on Papers and Program	F. H. Rhead				C. C. Bales J. S. McDowell L. C. Hewitt E. O. King M. C. Booze		
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[1] Special Committee on Feldspar specifications.

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BULLETIN
of the
American Ceramic Society

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical and Scientific Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIALS

CERAMIC SCHOOL CURRICULA

In the days when all shops were of small production there was no felt need for school trained men. The man who had sufficient imagination and creative ability to make a salable product had naturally the ability to find and to use the knowledge then available. The technical problems were handled sufficiently well by men schooled by experience.

Time was (and to many it still is) when skill of the "experts" was thought to consist more of knowledge of materials and mixtures than of creative and managerial ability. As a matter of fact formulas have been available for several decades to all who would read or who would purchase. Ceramic mixtures have been of value only to those who possessed vision and the creative genius of translating formulas into serviceable products. There can be no discounting the ability and economic value of the experience taught experts. Their worth can be fairly judged by the quality of wares they produce. It is the change in manufacturing conditions and the rapidly increasing quality demand that has made it necessary that the training of "experts" includes a thorough and broad searching of the fundamental sciences as applied to ceramics.

The "experts" needed by the manufacturers of refractories are those able to analyze the service conditions which the refractories must meet. These service conditions are increasing in variety and severity. New

products involving new methods of production are needed. The expert must explore the material resources and devise methods of manufacturing.

Such is the task of the "expert" in the production of any ceramic ware; glass, spark plugs, porcelain insulators, chemical wares, sewer pipe, hollow building tile, architectural products or enameled wares.

An Ideal Course of Training

How can a college best train men for service in the ceramic industries? Of what should the curriculum comprise? These questions are being asked alike by the instructors and by the employers. The instructors are anxious to prepare their pupils for the most efficient service and the employers wish to learn how best to use the pupils.

It is taken for granted that the collegiate course will include training in the fundamental sciences and in such cultural studies as will equip the pupil to creditably discharge his social and civil obligations. These are essential foundations for special ceramic training.

1. Ceramic Products

Rather than general lectures and laboratory exercises on porcelain compositions it would seem more beneficial to approach the study of porcelains from the service which porcelains must give. This would call for an analysis of the essential properties of porcelain products and the influence of constitution, structure, dimensions and shape on these properties. Porcelain now on the market could be tested and the conditions of use studied.

Such a study of ceramic products could be made on specimens of known compositions, designs and methods of manufacture. Most manufacturers would gladly coöperate with the colleges by making the test pieces and giving information regarding the essential properties. Both users and producers would collaborate with the colleges in devising means of testing.

The teaching of ceramic technology on this sort of program would necessitate a stock of test pieces that would be more than a museum of specimens. It would require access to quite a variety of testing apparatus but probably very few not to be found in University laboratories.

2. Ceramic Processes

Collegiate schools cannot furnish opportunity for practice in forming wares. A general knowledge of processes can be had by week end shop inspections or by scheduled plant visits.

There are some decorating processes which could be demonstrated and with which the pupils should obtain personal experience. Such demonstrations could be in the nature of laboratory work at the school or in a plant.

There are experiments in processes that could with profit be given, such as the use of electrolytes in casting slips and in plastic mixtures of

all sorts. These also could be in the nature of laboratory or plant demonstrations.

3. Ceramic Engineering

Every ceramic student should have a thorough course in drafting and designing including chemistry and thermo-dynamics of fuel burning and power production. It is important that the ceramist shall know how to conceive and to put his conceptions into working drawings.

4. Process Control

Control of manufacturing processes by analysis of materials and products, (measurements of temperature, drafts and pressures and of volume changes, etc.) will be the largest task of ceramic graduates. Compounding of mixtures and experimenting with new materials will continue for all time in any factory but the greater responsibilities will be in the instituting and continuing of factory control devices and methods. The larger the plant or the more exacting the specifications of product the more important is process control.

Pyrometry and other physical and chemical measurements would constitute a course in this ideal curriculum. Familiarity with precision methods and apparati is quite essential.

5. Promotion and Development of Products

If a graduate has not the ability to vision new uses, new products, new color or structural effects he will be doomed to routine services. This same appreciation of promotion and development applied to factory management is essential in large plant production. Lectures on promotion and development of products and human engineering is a cultural course which every industrial worker should take.

Summary

The ideal curriculum then would not stress compounding of ceramic materials. It would stress the essentials in process control and the production of wares to meet specific requirements.

It would develop the inventive ability of the pupils and give familiarity with precision methods and instruments. Rather than emphasize routine empirical mixing without vision of the exact requirements of the ware to be produced it would stress the reasons for the materials, mixtures and processes used. It approaches ceramic problems with the knowledge of what is wanted and a question of how to produce it. In this it differs from much of the present day school exercises of making a series of type mixtures with no other aim than to familiarize the students with the several types without more than inference to their possible industrial use.

Ceramic industries are today in need of experts who can produce wares that will meet exacting specifications. The colleges should be training their pupils to meet this need.

GREETINGS FROM PRESIDENT GREAVES-WALKER

The SOCIETY now has 2053 members on its roster.

It publishes a 170 page *Journal* each month.

The July *Journal* contained 95 pages original researches, 29 pages of abstracts and 47 pages of discussions and notes.

The SOCIETY has published 19 volumes of annual transactions and is now issuing Volume 6 of the *Journal.*

1278 pages of valuable material has been published this year including the July *Journal.*

The SOCIETY translated the Collected Writings of H. A. Seger and is now engaged in translating a new book by Dr. Singer.

The SOCIETY has published two bibliographies, has two in press and one in preparation.

It initiated and campaigned to successful issue the forming of Ceramic stations in the Federal Bureaus.

It assisted in the instituting and organizing of four collegiate ceramic departments.

The SOCIETY holds an annual convention in February for the presentation and discussion of papers, a "Summer Meeting" in August for plant visits, and a "Fall Meeting" in connection with the National Exposition of Chemical Industries for educational promotion.

The SOCIETY has seven Industrial Divisions; Art, Enamel, Glass, Heavy Clay Products, Refractories, Terra Cotta and White Wares. These Divisions have their own officers, committees and rules. They are self-governing and have a representation on the Board of Trustees.

The SOCIETY has seven Local Sections, the eighth one now under petition. These likewise are self-governing

This scheme of organization is an effective decentralization of activities through centralized assistance and coördination making possible unit coöperation with all other industrial and educational groups.

This is your SOCIETY, your opportunity and your duty to yourself and to the profession of your adoption. The ceramic industries will benefit from your continued and aggressive support, but yourself will be the more greatly benefited in proportion to the extent you actively serve in the affairs of the SOCIETY.

We should have many more than 2000 members. Our net increase this year is 19 less than it was last year at this t me.

The larger the membership support the larger will be the returns to each member.

We should have more corporation members.

Will you not present the SOCIETY'S past achievements and the present program of service to those who are not now members? Do this and your own returns will be greater.

PAPERS AND DISCUSSIONS

TRAINING OF ARTISTS FOR THE INDUSTRY

By J. Bailey Ellis

The College of Fine Arts is one of the subdivisions of the Carnegie Institute of Technology, which in turn is connected with Carnegie Institute and Museum. In the College of Fine Arts are housed six departments. We have as the oldest department the Department of Architecture; then we have a Department of Painting and Illustration, the Department of Music, Department of Drama, and the Department of Sculpture. The youngest department is the one I am especially interested in, which is called the Department of Applied Art. In this department we have a curricula which requires a general pursuit of certain courses for the first two years.

While each department is primarily interested in training its students for some specific field in the fine arts, the students are required during the four years they are with us to pursue certain courses in general studies as we call them, so that after the successful completion of any one of the curricula that student is eligible for a Bachelor of Arts degree. We give the required amount of English (two years of college English), two years of a modern language, history of civilization and general history of the arts, the history of costume, history of furniture, all strong history courses. We place these several courses into the curricula without interfering with the main part of the day in which the students can do their best work in the technical field. Most of these general studies come either in the early morning periods or the late afternoon.

In the Department of Applied Art, we require all of our students to follow a general curriculum for their first two years, because we believe that no matter in what field a student is eventually going to apply his art training, a certain foundation program and knowledge is necessary. Elementary design applies as much to some student who is going to function as a potter as it does to some one going in for costume designing or interior decoration. We think all of our students should acquire a certain ability to draw, to reproduce what is set up before them, therefore, this foundation training in the first two years.

Then, according to the way they develop, to the bent they show after going through these several courses, according to the thing they seem to feel they want to pursue, which very often is a complete change from the call that they had in mind when they first came to us, they may elect to specialize for their junior and senior years any one of five options. In each of these options it is possible for a student to make even a closer specialization.

First of all, there is a crafts option or craft specialization, and in that option we have pottery, jewelry and metal working, block printing and weaving.

A second option is given for costume design and illustration, where we are training students to design wearable costumes and makeable costumes.

We have an option in normal art, for the training of teachers to function in the public school systems or colleges throughout the United States.

There is another option in advertising and printing design, where our aim is to turn out a student who shall function, not as an illustrator, but as one who can illustrate, who knows something of color, of inks, of paper stuff, of type faces, who has had certain experience in type setting, in the processes of press work and reproduction. That student should be in position to take charge of the art end of an advertising establishment, or to be an art advertising man for a large printing concern. It is becoming more and more an accomplished fact that large print shops with a reputation are finding it well worth their while to go into the field of a complete job from the layout, the copy-writing through to the finished work.

Another option which we call Industrial Arts Design includes interior decoration, specialized furniture design, stained glass and wall paper design.

We have certain advantages at Carnegie Institute of Technology that no art school in the country has in equal proportion. The College of Fine Arts is one of four colleges, and in addition to the four colleges we have a division of general studies which takes charge of the faculties teaching the history, English and the languages courses, etc.

There are also a number of bureaus, coöperating with different concerns, making close contacts with business concerns and manufacturers outside of the College.

It is possible for the Department of Applied Art to so develop the curricula that a student who is specializing with us in costume designing can be sent over to the Margaret Morrison College to the department of costume economics for certain courses in draping, in dressmaking and pattern crafting. Students, therefore, who are not going to become dressmakers or costume economists primarily but who go into the costume fields, will have the opportunity of getting first hand information and experience in the technical and material limitations for which they are to design. It is also possible for any students following the advertising option to go into the department of printing in the College of Industries and have certain intimate experience with types and inks, because the department of printing has quite a complete shop within itself. And so on through the various options. By having departments in other colleges which are training students for certain fields in which art has a specific and legitimate use, our program offers close contact with the actual mechanical experiences, so that students can get a certain amount of that direct information neces-

sary to turn out a designer who can successfully design for the particular purpose or trade in which he is interested.

This is the thing we shall have to develop more and more in this country. There are a large number of schools turning out students, who after they have left school must gain the experience necessary to make what they have to contribute of value to the person or to the company in a position to give them a job that will bring in a certain amount of return. Anyone who is interested in the fine arts end of ceramics, necessarily a broader field than just pottery, will be interested in the organization which we have effected at Schenley Park. We have not been in a position to do very much advertising; we do not run our courses as a moneymaking proposition and, therefore, although we have grown very rapidly, we are not so well known outside of Pittsburgh and Western Pennsylvania as we would like to be, and as I think we deserve to be.

C. DRESSLER:—I should like to ask Mr. Ellis whether he is training people especially for the architectural work in connection with the fine art work, the subject which was last discussed?

J. B. ELLIS:—One of the departments, the architectural department, in its curriculum, has a certain amount of architectural modeling, and also includes students going into the Department of Sculpture and working out certain problems in clay. When we have sufficient faculty available, we shall be able to enlarge that work, so that they cannot only model the clay but do it with the idea that if the thing works out successfully, it can be fired and glazed.

W. D. GATES:—In Chicago there is now formed the Society of Arts and Industries, and they are planning the erection of quite a large addition to the museum and have it run under the Art Institute, for training in different lines in connection with the industries, and training young men and young women in the line of all these different industries. Considerable progress has already been made toward the fund for putting up this building.

A NOTE ON THE REQUIREMENTS OF SAGGER BODIES

BY M. F. BEECHER

In discussing the possible improvements in the quality of saggers it seems well to inquire first into the common causes for failure, and then to consider how and to what extent those causes may be eliminated. In making such an inquiry it would be advisable to separate those due to the character of the raw material from those due to the process of manufacture, to allow more careful study of each factor. This note will present some comments pertaining to the raw materials.

The materials of which a sagger is made are probably deserving of first

attention. In the past, clay has been almost universally used, but of late years newer and more refractory materials have been receiving study by manufacturers. And it should be had in mind that perhaps some of these new materials have properties other than simply greater refractoriness that might particularly commend them for sagger use. (By refractoriness is here meant, ability to remain rigid under normal load, under the influence of heat).

The first requirement of a good sagger is that it remain rigid at furnace temperatures (refractoriness). Lack of rigidity may be evidenced by softening (chemical failure) or by rupture in shear, tension or compression (mechanical failure). Chemical failure is due essentially to the character of the constituent materials resulting in low fusibility. Mechanical failure may be due to an insufficient amount of the bonding constituent, to volume changes taking place during use because of changes in crystalline structure, to diffusion of slags or to other causes. Since mechanical failures may readily arise from chemical changes within, or reaction between the constituent materials, no sharp line of demarcation can be drawn.

The other principal requirement is that it have good mechanical strength at room temperature, both originally and after continued service. Original high mechanical strength can be easily obtained, by the use of a strong bond in sufficient amount. The retention of that strength with continued use is a function of the material used and is the principal unsolved problem in this connection. In fact this is the really big problem in connection with sagger materials and mixtures. The means are at hand whereby selection of materials of suitable refractoriness may be made, and sufficient data are available to serve as a guide in their proper proportioning so that saggers originally strong at room temperature and mechanically rigid in the furnace can readily be made. Present practice readily demonstrates this. Service tests almost invariably disclose that every piece remains intact during the first three or four burns and then losses by breakage begin and continue at a more or less rapid rate. This means that the saggers were originally strong at room temperature and were chemically and mechanically rigid in the kiln, but after a few firings begin to weaken so that they are cracked or broken when drawn from the kiln or fall apart in ordinary handling.

The factors or properties which seem to be most involved in this deterioration are coefficient of expansion, modulus of elasticity, thermal conductivity and mechanical strength.

If sagger bodies did not expand and contract when heated and cooled the sagger problem would be a simple one. The expansion and contraction is in no case uniform throughout the piece for in no case is the sagger heated uniformly. Other conditions being equal then, that body which has the highest thermal conductivity will be under the least internal stress because

the temperature differential will be smallest. Also that body having the lowest coefficient of expansion will have the least internal stress because it will be under the smallest internal strain. Again, that body having the lowest modulus of elasticity will be under the smallest internal stress, for other things being equal, a given temperature differential would produce a given amount of strain. Obviously, that body having the highest mechanical strength in the kiln will remain unbroken the longest, when subjected repeatedly to this differential expansion and contraction.

The mechanical effect of this differential expansion and contraction is to produce fine cracks throughout the structure. These partially relieve the strain produced, but result obviously in a mechanical weakening of the piece. Since the mechanical strength decreases with the development of these cracks, the deterioration from this cause will continue from burn to burn. It is apparent then that the best sagger body is that one which develops these fine cracks at the slowest rate and that will be the body which has high thermal conductivity, low coefficient of expansion, low modulus of elasticity and high mechanical strength.

Before very substantial progress can be made, more data of this character on the available refractory materials are necessary. Silicon carbide and fused alumina have given indication of long life as saggers. The coefficient of thermal conductivity is high, being about 10 and 5 times respectively that of fire clay. Their moduli of rupture are high also in comparison and their coefficient of thermal expansion somewhat lower. Data on modulus of elasticity are lacking but they probably have no advantage over clay in this particular.

With a more careful study of these four properties of available sagger materials it is safe to say that much more durable and economical saggers can be produced than have ever been made before.

NORTON COMPANY
WORCESTER, MASS.

SAGGER COLLOQUIUM[1]

LED BY W. A. HULL

W. A. HULL:—Mr. Pence, as Chairman of this Division, has in mind a program of coöperative research on sagger problems.

F. K. PENCE:—Any attempt on my part to offer data at this time is premature. The Bureau of Standards is conducting an investigation on this subject in coöperation with certain manufacturers, particularly those of the U. S. Potters Association, but these investigations are not far enough along to give data.

The sagger problem naturally divides into two phases: the first being the behavior of the sagger in the raw state, and the second, the behavior

[1] Whitewares Division, Pittsburgh, Pa., February, 1923.

in use. In order that we may have a workable body in the raw state, the materials must possess satisfactory strength and drying properties. For this, modulus of rupture tests are being made on standard bars. In spite of the fact that considerable work has been done, we have failed to determine exactly what properties are required in the clays for saggers. The outlining of investigations to determine these properties is, in part, the task of the Research Committee of the Whitewares Division. I shall state very briefly the line of attack we have in mind.

All other considerations aside, we should probably select those clays which have the greatest strength in raw state. To determine this strength a standard test bar 6 inches long and one square inch cross-section is made and tested when dried. In the forming of these test bars care is taken that there are no laminations, cracks or molding faults. It may be formed by rolling in the hands, placed firmly into a brass mold having a movable bottom, the surplus clay cut off with a fine wire and the bar then removed carefully and air-dried for three or four days; and finally dried at 105° to 110°C. It is then placed in a dessicator and tested moisture free.

The other observations on the raw clay are (1) drying shrinkage and (2) the sticky quality.

A close sticky clay may dry with great difficulty no matter what the shrinkage. Black sticky clays are of that nature. A clay with low drying shrinkage is desired. Usually the clay of greatest strength has the greatest drying shrinkage.

Having the modulus of rupture in the raw state the next test is the fire shrinkage. This shrinkage is important.

The sagger should be of the highest mechanical strength when fired to withstand the breaking strains in handling and the load strains in use. Frequently high mechanical strength is obtained only at the expense of ability to withstand rapid temperature changes. As a rule the more porous saggers will best withstand temperature changes, hence it is that for some purposes either strength or porosity must be sacrificed and in all cases a workable balance obtained. We cannot have maximum strength with maximum resistance to breaking due to sudden temperature changes.

The general ware industries have found that an absorption of 14% to 15% was most satisfactory. This would not be suitable for all industries. It was determined that 14% or 15% absorption gives a body fairly open and yet of sufficient mechanical strength.

The Bureau of Standards will make porosity and strength tests. Such data should be correlated with modulus of rupture on standard bars made of the clays.

We want to be able to say that a sagger for a given purpose must have a certain mechanical strength and that if a sagger in question does not have this strength the chances are that it will not serve.

The control of firing shrinkage by the amount of grog and the resultant effect on strength is important. What is the effect of 40% grog as against 50%? We must use grog and yet we cannot overload the bond clay with it. Forty per cent or more grog is quite usual for general ware. At first I was of the belief that this was too much grog. When more grog is used than the bond clay can carry the saggers will not stand up; they will settle under load. This could not be allowed in the case of pin saggers for the alignment of the pin holes must be maintained.

Is the size or the range in size of the grog of importance? Can we use coarser grog in case we use less?

It may be difficult to lay down absolutely a rule for any of the white wares industries, but for given conditions of load and heat treatment *I am sure* that rather definite and useful data can be obtained.

We shall work out a questionnaire in the Bureau of Standards regarding the working properties of clays in the raw state including such properties as strength, drying shrinkage and the amount of grog that each can carry, the mechanical strength fired as determined by modulus of rupture on standard bars, the effect of repeated heat treatment as perhaps indicated by firing test bars repeatedly and testing, and resistance to sudden change of temperatures.

Recently I saw a rig to determine the resistance of spark plugs to sudden temperature changes. They revolved the carrier over a flame thus subjecting the plugs to alternate high and low temperatures. The number of revolutions were recorded and from this the number of alternate heating and cooling which each plug sustained before cracking was known. Some such tests would give valuable data on saggers.

The Bureau of Standards is in a position to determine the properties of sagger clays at different firing temperatures. They have such data for ball clays. A study of the vitrification range of sagger clays is important as was shown in Purdy's original work in Illinois on paving brick clays.[1]

The object of this colloquium is to obtain the largest possible coöperation in investigation of saggers and sagger materials.

W. A. HULL:—There is no question but that Mr. Pence is an optimist as to what we are going to do this year, but there are some of the potters who are already doing parts of this work which Mr. Pence has suggested. Some of the potters are testing their own clays. Some may be doing work on the properties of sagger mixtures, and perhaps making tests that Mr. Pence has suggested. The Bureau of Standards would be glad to get in touch and compare notes with as many of such laboratories as care to do this.

In work of this sort, a certain amount of effort will be lost, not so much

[1] R. C. Purdy "Paving Brick and Paving Brick Clays of Illinois," *Bull.* 9, Ill. State Geol. Surv. (1908).

due to overlapping as to the fact that one investigator will run against snags that perhaps some other investigator has already found a way around. If a number of factory laboratories will do such work as they can along lines that Mr. Pence has suggested and such other lines that may suggest themselves, and will pool results through the Bureau, all who thus participate will profit. We have given publicity to the fact that we are working on these problems and have sent out for material. Some offices have a follow-up system apparently and want to know soon if there are any results. The more laboratories working on this subject the fewer inquiries we are going to have to answer at the Bureau of Standards. The term "Bureau of Standards" is used as an all-comprehensive term which indicates an enormous capacity for work. When we started on this sagger investigation we looked for a year and a half before we found one man suitable to put on it. Now we hope to have funds enough to give that one man some assistance.

As Mr. Pence has already stated, there are two things we have to consider. (1) The properties of the materials that go into the saggers (2) the properties of the finished saggers. The refractories people are charting the conditions to be met by refractories in use. By thus listing the properties required they will determine the suitability of refractories for specific purposes. If the properties needed in a sagger are known, we then have an intelligent basis on which to search for the required materials with which to fabricate and the method of fabricating to get the best results.

A. V. BLEININGER:—Messrs. Pence and Hull have already covered the subject of tests so thoroughly and comprehensively that there is very little to add. I shall refer, however, to the mode of preparation. I have always been impressed by the fact that if a man was instructed to devise the very poorest method of mixing and preparing a sagger mix, he would probably hit upon the way in which most potters are doing it. The old time-honored soakpit and the system under which it is operated, the method of incorporating the grog, the method of operating the pug mill, which is easily the worst piece of apparatus on the plant, all contribute to the fact that the resulting product is bound to be of uncertain quality. Frequently I wander through a sagger shop and examine the prepared material ready for use and note the lack of homogeneity in the sagger body.

I believe that making of good saggers is intimately associated with proper preparation. This, we all agree is a thing in which we must bring about a profound change if we are to get better results. This is one thought we must keep in mind.

We must realize also that the laboratory tests involve methods of preparation which are very much better than those in actual use and hence the results must be judged accordingly.

I should like to second the Chairman's suggestion that we study the resistance of sagger bodies to thermal shock. The Refractories Committee of the American Society for Testing Materials has already attacked this problem.

One other suggestion is that we determine the after-shrinkage of the prepared sagger body subsequent to the first firing. This is a very important fact, because if you have a sagger body which contracts in use under load imposed on it, it is evident that you are subjecting the sagger to a very heavy stress. Hence it is important that the after-shrinkage be reduced to the minimum. I believe we have here the keynote of a vital point not heretofore considered.

It is not so much the initial shrinkage we desire to know but the after-shrinkage in the second, third, fourth and fifth fires. This should be followed up with considerable care.

H. GOODWIN:—We all realize that saggers are an important problem and that they will be important as long as we are in the business. At St. Louis last year we had this under discussion[1] and it was agreed that certain lines should be followed. I am somewhat disappointed that we do not have further data to be presented at this meeting. I fully realize and agree with all that has been said. We are working in the dark with the sagger problem. It is just as necessary for the sagger mixture to be right as the body. Can anyone tell results obtained last year at St. Louis, when a motion was made that the SOCIETY take up the matter with the United States Potters Association and the Bureau of Standards.

A. V. BLEININGER:—This matter was not neglected. It was taken up and duly presented to the U. S. Potters Association and they have responded to this and to other suggestions by appointing a research committee. Your Chairman is a member of that Committee. The proposed sagger investigation was discussed quite fully and we came to the conclusion that we must first secure all of the preliminary information possible. Before making an appropriation of the magnitude mentioned, preliminary studies are needed.

There is available a rather large amount of information which should be gathered together before much money is spent. The U. S. Potters Association is making a study of this field and will be ready to coöperate with this SOCIETY as soon as the situation has been clarified. There are a number of aspects of this important problem that must be considered carefully.

W. A. HULL:—Has anybody any standards on the strengths or moduli of rupture of sagger mixtures? Someone may have determined this from his own experience. Mr. Bleininger, how strong should the three types be?

[1] See C. C. Treischel, "Coöperative Research on Sagger Mixtures and Manufacture" and Discussion, *Bull. Amer. Ceram. Soc.*, **1** [7], 101–6(1922).

A. V. BLEININGER:—I could only make a guess, but we can give you definite information along these lines from our records. We should be glad to give you the figures we have obtained at our plant and Mr. Pence would do likewise. In addition, Mr. Pence has conducted for our Research Committee a series of tests which he will report in the near future. I think I can speak for most of the pottery companies that they would be glad to assist in every way.

W. A. HULL:—We do not want to write to all the pottery companies and ask them individually, but I assure you they would be welcome.

A. V. BLEININGER:—The Research Committee of the U. S. Potters Association will be glad to furnish all the information it can.

W. A. HULL:—That is the proper channel. As already more or less advertised, the Bureau is undertaking to do some work along the lines of the sagger problems but we cannot do much more than make a beginning in a year. We have requested manufacturers to send in samples of the clays they are using. The plan was to make a survey of the properties of the important types of sagger clays now in use as a basis from which to plan a systematic investigation, very much along the lines which Mr. Pence has indicated. We have determined some of the properties of fifty-five clays. Those will undoubtedly resolve themselves into groups of clays with similar properties. Then we propose to make mixtures in the laboratory duplicating as nearly as possible some of the successful mixtures that are in use so that we can obtain data on measurable properties of these factory-tried mixtures, thus having a basis for comparing laboratory saggers with factory-made saggers.

We then propose to make some mixtures of our typical clays and compare their properties with those of mixtures in use.

As means of studying the progressive changes that go on in successive burns that the sagger goes through, we are going to ask some of the potteries to fire test bars made in the Bureau of Standards under conditions that admit the least effect of the personal factor in the preparation of the specimens. From each successive firing, test bars of each sagger mix will be sent back to the laboratory to be examined and tested. We can thus find what develops from the repeated firings. I do not think there is any question in anybody's mind but what the sagger deteriorates in some way due to its repeated heating and cooling. We believe that the kind of deterioration, the nature of the change and the extent of it, depends on the nature of the mix and in the kind of firing to which it is subjected.

What investigations have been made have been for the most part with a view to getting results rather than getting explanations and the Bureau of Standards particularly should be able to go a step further.

It is readily understood that the undertaking of this investigation be-

ginning with the clays themselves and following with different mixtures of clay and grog is a big job. I wish to speak for the investigators your coöperation and your patience.

M. R. HORNUNG:—The biscuit sagger carries a heavier load than that on the bottom whereas the glost sagger carries a lighter load oftentimes on pins projecting from the sides of the saggers. The glost sagger which carries only a few pieces of hollow ware on the bottom certainly ought to require a different sort of sagger than that for the biscuit.

We have made saggers out of fine grog and it is surprising how they have lasted. But it is hard to dry them. They must be thoroughly dried before firing.

The machine-made saggers differ from the hand-made. For equal service results, the properties of the saggers by these two methods differ a great deal.

G. E. SLADEK:—We use a 50% grog body for our machine saggers and we seem to have fair luck with them. We have had our share of friable saggers, and we also have a little trouble with glost saggers.

When we first started to fire coal in our periodic kilns, the wads stuck. This difficulty was eliminated by a slight change in the design of our fire box, by which oxidizing conditions were obtained. This seemed to have a marked effect on the life of the saggers. We have had very good luck, however, for three years.

Another point is that we keep account of the number of saggers broken in handling and the number coming out of the kiln broken. The average is three broken on drawing for one broken in the handling.

W. A. HULL:—Does anyone want to contribute from his experience in the casting of saggers?

A. V. BLEININGER:—Some cast saggers were made at our East End Pottery. There is promise of improved quality but from the standpoint of cost our experience so far is not promising. Our general superintendent, Mr. Walker, has studied the subject but what information he has obtained indicates that the process would be more expensive. Also the question of room was a serious one, where all the space is taken up already by manufacturing processes. Some work in this connection has been done by the Mount Clemens Pottery Company. Similar work has also been done by Mr. Brain of the Standard Sanitary Manufacturing Company. They have had good success with the cast saggers.

The casting itself is promising from the standpoint of quality but there are other questions coming in. If you begin to figure on the number of molds required I think you would get rather astonishing figures.

H. GOODWIN:—The question of kind and percentage of grog has been brought up. Frequently factories run short of biscuit grog and have to resort to broken glost saggers. A successful manufacturer told me that

he calcined sagger clay, so much of it in each kiln to maintain the quality of his grog. I have found that very successful. The use of glost saggers for grog will bring trouble. The size and quality of grog must be under control if we are to make saggers of the greatest mechanical strength.

T. A. KLINEFELTER:—We have not been casting saggers long enough, nor in sufficient quantities to get well-analyzed or the lowest costs, but at present they are costing between two to four times the ordinary saggers. While I cannot give definite data on the life of cast saggers there is a general understanding that they are lasting twice as long.

Cast saggers come straighter and you can pick them out from the rest. I attribute the straightness to the more thorough mixture. There have been papers read in the Terra Cotta Section about making tile, which is exactly the same proposition, in which was brought out the fact that good mixing and proper pressing was often more effective in producing good quality tile than was the selection of clay.

F. K. PENCE:—At Zanesville we came practically to the same conclusion. The cast sagger was very satisfactory but with proper mixing the plastic sagger was made nearly as good.

A MEMBER:—In New England they still use the old wheel chaser. At one time they thought that method was antique. They installed a wet pan but it failed completely. They then went back to the wheel chaser. This is an old-fashioned device; a big cart wheel on a ratchet that causes the wheel to travel from the center to the outside of the pan. The clay and grog is soaked overnight. This procedure gives a very homogeneous product.

H. GOODWIN:—If I can be of any service to Mr. Hull, and he wants anything from me, I shall be glad to send it to him.

A. S. WATTS:—The following data is taken from a thesis by D. M. McCann.

Ingredients	
No. 5 Fire Clay (Lower Kittaning)	Fuses Cone 32–33
X Wad Clay (Tennessee)	Fuses Cone 28
Ball Clay (Hazel, Ky.)	Fuses Cone 31
Grog (4- to 16-mesh)	Fuses Cone 31

Clays ground to pass 20-mesh sieve.

All mixtures soaked 24 hours, put through pug mill 3 times, then soaked 24 hours and pressed in steel die. The trial pieces were solid cylinders 6 inches long and 7 square inches across sectional area. They were fired to cone 2 and then sent to the Mosaic Tile Company, Zanesville, Ohio, where they were fired at cone 10. One third of each set was fired at cone 10, once, another third was fired at cone 10 five times and the third set was fired at cone 10 ten times.

The best body had a composition of 20% ball, 7½% wad and 22½% first class fire clay, 50% grog. The second best had a composition 27½% sagger ball clay, 22½% fire clay, and 50% grog. The general conclusions found from this study were that ball clay weakens in excess of 25% while the fire clay and wad clay have about the same

strength. Additional fire clay increases the strength up to 22½% when mixed with ball clay. There is a slightly increased strength with the addition of wad clay. We found better saggers with the fire clay, ball clay and wad clay mixture than with ball clay and wad clay or ball clay and fire clay. The values vary from 300 pounds to the square inch to 1100 pounds to the square inch. Some manufacturers have sagger mixtures very similar to No. 7.

	Composition				Crushing Strength of Trial		
					Load test	1330°C	
No.	Ball	Wad	Sagger	Grog	1 burn lbs.	5 burns lbs.	10 burns lbs.
1	20	30	..	50	7000	6200	6100
2	20	22.5	7.5	50	6666	6500	6320
3	27.5	22.5	..	50	3930	3950	3920
4	20	15	15	50	6950	6950	6860
5	27.5	15	7.5	50	7400	6265	6100
6	35	15	..	50	6450	5100	5000
7	20	7.5	22.5	50	8000	7500	7000
8	27.5	7.5	15.0	50	4300	4100	3720
9	35	7.5	7.5	50	7000	6830	6450
10	42.5	7.5	..	50	1950	1620	1820
11	20	..	30	50	4550	1580	4550
12	27.5	..	22.5	50	8000	7500	6400
13	35	..	15	50	5500	3200	3100
14	42.5	..	7.5	50	1900	2050	1680
15	50	..	..	50	2020	2000	2000

H. GOODWIN:—Years ago I made several tests using New Jersey clays with 20% fire clay, with good results, although fire clay is not extensively used. Prof. Watts' report bears out my experience.

W. A. HULL:—Is that not more generally done because fire clays are not used in potteries?

H. GOODWIN:—Most factories keep a small stock of fire clay for the repairing of kilns. We always keep it on hand and I do not know why we have not used it more extensively. During the years 1920 and 1921 we had about 6% fire clay in our sagger mix.

W. A. HULL:—Is the strength of the dried mixture an index of the strength of the burned mixture and is there any relation between the two? Has anybody ever tried a sagger mixture more refractory than necessary and burned at a higher temperature? Has anybody tried burning saggers the same as for refractories?

H. WILSON:—Our experience might be strange to some here. I found we could increase the life of saggers 50% by reducing the first heat. We first fire at a lower temperature thus, we believe, adding to the life of the sagger. That is contrary to Mr. Bleininger's experience.

W. A. HULL:—Where do you burn them?

H. WILSON:—We burn a kiln of saggers at about cone 8, while cone 12 is the heat in which they are used.

H. GOODWIN:—Relative to the life of a sagger first fired at a lower

temperature my experience has been that such saggers when used in glost kilns give considerable trouble due to new saggers being larger. No matter how carefully the wad has been put on it will shrink away leaving a fissure from $^1/_8$ to $^1/_4$ inch. There is also the added danger of the bungs collapsing due not only to the saggers being of different sizes, but to the fact that the new saggers burned at a lower temperature cannot carry the weight of a bung of loaded saggers. It may be all right with you, yet it is a dangerous practice.

W. J. THROWER:—I will have to agree with Mr. Wilson with regard to the firing of green saggers to a heat below that at which they are used. For a period of 18 months we have been firing our green saggers at about cone 5 or less. This materially increases the life of saggers.

That idea was given to me by a very old kiln fireman. He could not present an argument to justify it. He knew it. We tried it and have never quit it. From our experience I will agree it works satisfactorily.

There is no question but that one of the greatest things today in the making of saggers is the preparation of the clay. During the war everybody let down on quality. The men would put the clay into our soaking pits 15 inches thick. They would put the allowance of grog on that and then 14 inches more of clay. There was a loss of about 50% in the saggers. We then made each layer only 6 inches thick. Any clay in lumps had to be broken up or partly pulverized. On that 6 inches of clay was put its quota of grog. Thus the pit was built up until we got eight layers instead of three. Instead of having a 50% loss, it ran around 8 or 9%. There was no change in sagger clay. It is a question of the proper mixing of clay. I should like to ask Mr. Bleininger if he used the same mix as is generally used.

A. V. BLEININGER:—I think the regular mixture was used except it may have been somewhat finer grog.

W. J. THROWER:—We should devise some means of crushing so we can mix the clays before putting them into the pit, if we still use the pit.

H. SPURRIER:—Two points occur to me. The amount of water used in tempering the mix is a matter of importance and the drying also is another point of considerable importance. If you conceive of a sagger mix as merely a body cemented together, your grog does not lack in size or shape, whereas your clays do and you have to consider that you have a body cemented together. It is delicate.

Some have maintained that if saggers were dried in a drier the life would be increased. I have never seen saggers dried with such care but I am quite ready to believe it would add to the life of the sagger. Moreover I do believe the saggers are handled far too rough'y. They are delicate prior to the firing.

A. S. WATTS:—A client of mine used four kinds of sagger. These,

previously finely crushed, were shoveled with 4- to 16-mesh grog into a brick machine equipped with a nozzle that gave a 6-inch square column of stiff mud consistency. The grogged mix thus pugged was piled and allowed to age for three weeks covered with wet burlap. Saggers were made by the ordinary hand pressing.

They thought it was not necessary to crush the material so fine, so after the first batch of 160 saggers, they made another lot with coarser clay and pan run of grog. Saggers thus made failed whereas the manager said the first lot of saggers lasted until they were "ashamed of them."

F. CERMAK:—We have mixed clay for 8 years at the General Electric Company in an 8-foot pan. We make a batch of 600 pounds which runs from 8 to 10 minutes. We do not use a soak pit.

A. S. WATTS:—About firing saggers: the most severe treatment green saggers receive is in the original burning. In a stack of green saggers, twelve high, the one on the bottom is drying and firing under an enormous load. Then we wonder why they do not come out strong. The saggers burned on the top of the kiln, two or three on a bung are the best. If, when it is necessary to boost the production of the saggers, the green saggers are stacked five or six high the result is inferior saggers. They are unduly strained.

W. A. HULL:—We started out with a misconception of the situation, stating sagger troubles, and it looks as though all we have to do is to make saggers the best we know how. Nobody appears to be doing it. What is the use of an investigation if we know about it all the time and let our bad practices go on?

The problems of proper choice of materials, their compounding and burning are being investigated by the Bureau of Standards. The Research Committee of the U. S. Potters Association is collaborating and it is the purpose of the Research Committee of the White Wares Division of this AMERICAN CERAMIC SOCIETY to participate in this work.

SERVICE CLASSIFICATION OF FIRE BRICK

Committee C-8 on Refractories of the American Society for Testing of Materials has adopted a scheme looking toward a service classification for refractories. At the present there is a classification based on fusibility in grades 1, 2, 3, and 4 but this has been without value to either the producer or consumer. By this new classification based as it is on the properties required to meet service conditions, the service rather than the bricks will be classified and numbered and be the basis on which specifications will be written. All bricks which possess the properties required to meet a given service will be known according to the service it will render. Ser-

vice rather than bricks being thus classified, a given brick may serve in as many classifications as tests and service will prove it to claim.

The complete report of the committee follows.

Policy of Committee C-8

This special Committee has given a great deal of thought to the matter of formulating a definite policy for the work of Committee C-8, and as a result of its work, makes the following proposal:

In order that Committee C-8 should function most efficiently, so that it may be of the greatest service to both the producers and users of refractories it is felt that the present plan of organization should be revised and that a new form of organization should be set up in which the Chairman should be relieved of the responsibility and detailed work of the Sub-committees and that this responsibility should be vested in a coördinating Committee which in the proposed By-laws is called an Advisory Board composed equally of producers and consumers. This form of organization is set forth in the proposed By-laws at the beginning of this report.

With this new form of organization the work of the Commiftee should proceed along the following lines:

(*a*) The formulation of a Service Classification of Refractories. This has been undertaken by your Committee and is made a part of this report.

(*b*) An Industrial Survey of furnaces and furnace conditions in accordance with this Service Classification. This work is to be taken up by the Sub-committee on Industrial Survey.

(*c*) The definition and interpretation and further development of the tests. A proposed Sub-committee on Tests and Specifications will undertake this work.

(*d*) The preparation of specifications. This work will be done by a Sub-committee on Tests and Specifications in coöperation with the Sub-committee on Industrial Survey both working together under the Advisory Board.

In the matter of drawing specifications, the Committee proposed that it shall be the policy of Committee C-8 to draw specifications only for general classes of refractories for which there is a commercial demand and not to draw specifications for special isolated requirements.

In order that the work of the Sub-committee on Tests and Specifications through its section may go forward with maximum efficiency and coordination, it is recommended that each section should adopt the same method of attack.

(*a*) That the first step should be the preparation of clear cut definitions of the property that the section is studying.

(*b*) That a careful study should be made of the various tests with a view to developing limitations and the proper interpretations of their results.

(*c*) That special attention should be given to the adaptation of each test to its use in specifications and that further developments should be immediately studied. Many of our present tests are not adapted in their present form to application in commercial specifications.

Service Classification

This special Committee has felt that one of the most important pieces of work it had to perform was to formulate a classification for refractories based on service conditions. It believes that in the final analysis it is service that the consumer purchases and that no method of classifying refractories could be satisfactory that is not based upon this principle.

SERVICE CLASSIFICATION OF REFRACTORIES			LOAD								
			UNIMPORTANT			MODERATE			IMPORTANT		
			ABRASION UNIMPORTANT	ABRASION MODERATE	ABRASION IMPORTANT	ABRASION UNIMPORTANT	ABRASION MODERATE	ABRASION IMPORTANT	ABRASION UNIMPORTANT	ABRASION MODERATE	ABRASION IMPORTANT
SLAG ACTION	UNIMPORTANT	SPALLING UNIMPORTANT	1	2	3	4	5	6	7	8	9
		SPALLING MODERATE	10	11	12	13	14	15	16	17	18
		SPALLING IMPORTANT	19	20	21	22	23	24	25	26	27
	MODERATE	SPALLING UNIMPORTANT	28	29	30	31	32	33	34	35	36
		SPALLING MODERATE	37	38	39	40	41	42	43	44	45
		SPALLING IMPORTANT	46	47	48	49	50	51	52	53	54
	IMPORTANT	SPALLING UNIMPORTANT	55	56	57	58	59	60	61	62	63
		SPALLING MODERATE	64	65	66	67	68	69	70	71	72
		SPALLING IMPORTANT	73	74	75	76	77	78	79	80	81

Temperature indicated by prefixing proper letter to number.
H = High Temperature
M = Moderate "
L = Low "

Example: M-21 indicates moderate temperature, unimportant load, unimportant slag action, abrasion and spalling both important.

FIG. 1.

A number of modifications of the idea have been proposed and examined. Several plans, while they had the merit of being concise, were open to certain objections in that they involved assumptions regarding the mutual dependence of certain properties. The final basic classification chosen by the Committee as being its opinion free from such objections is shown in Fig. 1, attached herewith.

This classification involves five fundamental qualities, *viz.*, tempera-

ture, load, abrasion, slagging and spalling, and has assumed that there may be three degrees of resistance required for each quality, *viz.*, unimportant, moderate and important. Such a classification as given in the diagram results in eighty-one possible classes. It is believed that the classification is sufficiently comprehensive to cover all possible requirements and should, therefore, be free from objections which would have been raised to some of the more concise forms previously mentioned.

On studying this comprehensive scheme, the Committee was struck by our present meagre knowledge of the requirements for many of these classes and it was believed, for the present at least, that it would be better to commence our work on a simpler scheme of classification that should be so chosen as to be capable of expansion, at any time should the demand arise, into a more comprehensive form. The Committee believes it has accomplished this simplification by using a comprehensive scheme as a foundation, and by choosing for our preliminary form the four classes taken at each corner of the main structure. These are indicated in the plate by the crossed hatched squares (Fig. 1). It will be noted that this is simply omitting for the present, one of the degrees of variation in each of the fundamental qualities, *i. e.*, the moderate degree.

CLASS H, M, OR L	TEMPERATURE	ABRASION	LOAD	SPALLING	SLAG
1	Yes				
3	"	Yes			
7	"		Yes		
9	"	Yes	"		
19	"			Yes	
21	"	Yes		"	
25	"		Yes	"	
27	"	Yes	"	"	
55	"				Yes
57	"	Yes			"
61	"		Yes		"
63	"	Yes	"		"
73	"			Yes	"
75	"	Yes		"	"
79	"		Yes	"	"
81	"	Yes	"	"	"

FIG. 2.—Summary of tests required.

This simplified scheme, then, gives only 16 classes, which it is believed will be ample for our present purpose; and yet these 16 classes are so chosen that, should the demand arise in the future, the further extension may be readily inserted without destroying the work that has already been done. By adopting this scheme, the work will be brought to within a reasonable compass in view of our present knowledge of furnace conditions and requirements.

In Fig. 2 herewith is given a summary of the test requirements for the different classes of service in accordance with this scheme of service classification. It will be noted that the test requirements for Class 1, for instance, are merely that of temperature, whether it be high, medium or low. These

test requirements increase to five in Class 81 which would have a requirement for temperature, abrasion, load, spalling and slagging. This second diagram should be of great importance in directing the work of the proposed sub-committee on tests and specifications. It indicates that at the present time we are only in a position to write specifications for Classes 1, 7, 19 and 25 and as a matter of fact, our existing load test and spalling test will both require revision to adapt them to use in specification. This summary also points out the necessity for immediate work in developing a suitable test for abrasion and slagging.

It is believed that the proposed by-laws will cover many of the situations which have handicapped Committee C-8 in its work in the past. The proposed scheme of organization will relieve the Chairman of the immediate responsibility for the work of the sub-committees and place this responsibility on the Advisory Board. Our past experience has indicated

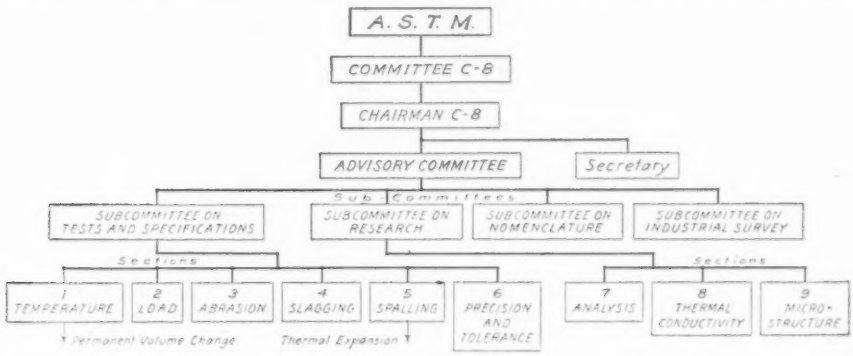


FIG. 3—Proposed organization Chart of Committee C-8.

that this will be a desirable form of administration. Under these By-laws, the organization of the Committee will be in accordance with the organization chart attached to this report.

Under the Chairman will be the Advisory Board, and under the Advisory Board will be the four standing Sub-committees, *viz.*, Tests and Specifications, Research, Nomenclature, and Industrial Survey.

The Sub-committee on Tests and Specifications will have as required under the proposed service classification, sections on Temperature, Load, Abrasion, Slagging and Spalling, which are the standard tests and in addition a section on Precision and Tolerance which will, as in the past, continue to make a critical study of the results obtained by the various proposed methods. This Sub-committee will be charged with the development of Standard Tests and Standard Specifications.

The Sub-committee on Research will consider all of those subjects which at the present time are not immediately applicable to specifications

so that at present it would have sections handling Chemical Analysis, Thermal Conductivity, and Micro Structure. This Sub-committee would automatically handle any new method of testing or investigation. The Research Sub-committee would also be available to assist any of the sections of the Sub-committee on Tests and Specifications.

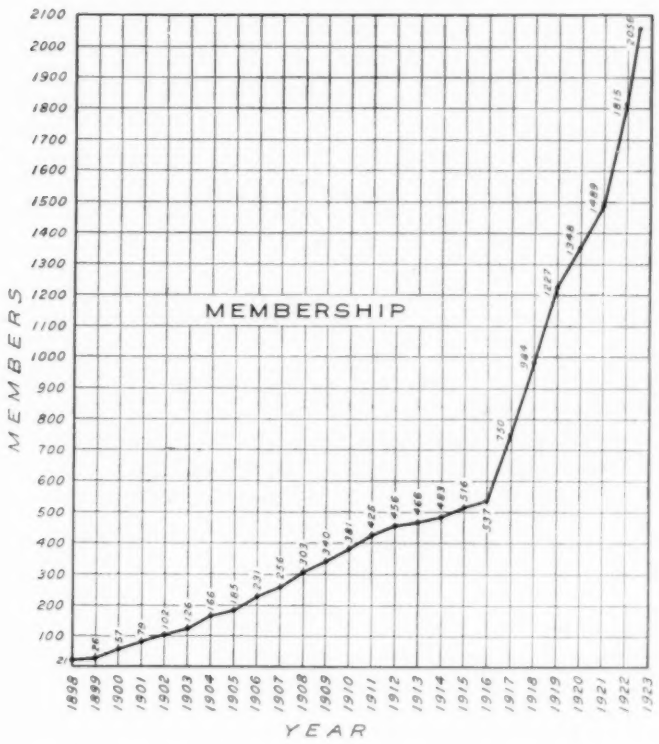
The Sub-committee on Nomenclature is more or less a formal Committee appointed at the request of the Society to coördinate the work of Committee E-8 on Nomenclature with the work of the Standing Committees.

The Sub-committee on Industrial Survey will report on the classification of furnaces and furnace conditions in accordance with the standard form of service classification presented in this report. This Sub-committee, of course, will coöperate under the Advisory Board with the Sub-Committee on Tests and Specifications.

It will be noted that the present form of organization has eliminated several of our present Sub-committees. Their work will be merged with certain of the sections of the Sub-committee on Tests and Specifications; for example, the work on Permanent Volume Change will be handled by the Section on Temperature, and Thermal Conductivity will be handled by the Section on Spalling. The present special Committee on Magnesite will be discontinued as the proposed scheme of service classification does not require such sub-division.

ACTIVITIES OF THE SOCIETY

WE HAVE MORE HORSE POWER BUT NO MORE SPEED—WHY?



Twenty personal and six corporations is our June 15 to July 14 record of acquisitions. Growth in membership is shown here graphically.

NEW MEMBERS RECEIVED FROM JUNE 15 TO JULY 14

PERSONAL

Campbell, Thomas, Wunderlich Ltd., Box 474, Sydney, New South Wales, Australia, Works Manager.

Cartwright, George, P. O. Box 2, Darby, Pa., Proprietor, Darby Fire Brick Co.

Decker, William More, Jr., 32 St. James Pl., Buffalo, N. Y., Secy.-Treas., Hygeia Glass Corp., Lancaster, N. Y.

Gevy, Addison H., Glen-Gevy Shale Brick Co., Shoemakersville, Pa., Superintendent.

Greenlee, Fred W., Linerville, Ia., Student.

Hysell, Eugene J., Buckeye Tile Co., Chillicothe, Ohio, Vice-President and Manager.

Lunn, C. A., Consolidated Gas Co., of New York, 130 E. 15th St., New York City, Chief Chemist.

Menart, E. G., 67 Neal Ave., Newark, Ohio, Enameling Superintendent, The Wehrle Co.

Miller, C. F., c/o Root Glass Co., Terre Haute, Ind., Chemist.
Nyar, Mulkh Raj, Box 43, W. Lafayette, Ind.
Owen, Thomas Wilfred, 1104 145th St., East Chicago, Ind.
Rice, William E., 42 Rice St., Alliance, Ohio, Fuel Section, U. S. Bureau of Mines, Car Manager, Laboratory Car "Holmes."
Sanborn, Paul H., Chemist, Jeffery-Dewitt Insulator Co., Kenova, W. Va.
Seiler, Carl, 860 Drexel Bldg., Philadelphia, Pa., Representative of the Roessler and Hasslacher Chemical Co.
Scott, W. J., Room 141, Industrial Bldg., Bur. Standards, Washington, D. C., Junior Engineer, Ceramic Division.
Serpa, Frank, Rehoboth, Mass., Superintendent, Enameling Plant, Rehoboth Enameling Co.
Stephenson, W. S., 1321 Widener Bldg., Philadelphia, Pa., District Manager, The American Rolling Mill Co.
Suit, Harry Franklin, 214–12th St., N. W., Washington, D. C., Plating and Polishing.
Turk, Richard, 116 W. Hamilton Ave., Hamilton, Md., Porcelain Enamel and Mfg. Co.
Wilcox, Bernard, c/o Smith and Stone Electrical, Georgetown, Ontario, Foreman.

CORPORATION

Bryce Brothers Co., Glass Mfrs., Mt. Pleasant, Pa., G. S. Bryce, Treas. and Gen. Mgr.
The Electro-Alloys Co., Taylor St., Elyria, Ohio, J. B. Thomas, Treas.
A. D. Poclim & Co., Ltd., Salford, Manchester, England, David T. Taylor, Director.
The Roseville Pottery Co., Zanesville, Ohio., Russell T. Young.
United States Sanitary Mfg. Co., 1707 Arrott Bldg., Pittsburgh, Pa., A. H. Cline, Jr., Secy.
Peoples' Gas Light and Coke Co., 122 S. Michigan Ave., Chicago, Ill. H. H. Clark, Fuel Engineer.

The members who are actively engaged in securing new applications for membership are shown in the following list:

Name	Personal	Corporation
N. E. Loomis		1
Donald E. Sharp	1	
Paul E. Cox	1	
P. H. Swalm	1	
R. D. Landrum	1	
F. C. Flint	1	1
R. K. Hursh	1	
W. L. Shearer	1	
Karl Turk	4	
H. H. Clark		1
Office	9	3

Total 20 Personal, 6 Corporation

WHO'S WHERE IN THE AMERICAN CERAMIC SOCIETY

Howard C. Arnold of St. Louis has moved to 5305 Delmar Blvd.

E. B. Baker of the Detroit Star Grinding Wheel Company is living at 764 Military Ave., Detroit, Mich.

Fred S. Bell of the Mandle Clay Mining Company gives as his address, 6645 Waterman Ave., St. Louis.

Richard Broadley, formerly of Champaign, Ill., has moved to 528 E. Jackson St., Mexico, Mo.

H. D. Callahan of Columbus is now with the Northwestern Terra Cotta Co., 2525 Clybourn Ave., Chicago, Ill.

Benjamin F. Carter of Peoria, Ill., writes that he is now living at 5905 Madison Ave., Bartonville, Ill.

Bertram L. Cassady, whose name has been listed among those whose addresses are unknown is with the Wellsville Fire Brick Co., Wellsville, Mo., with headquarters at 144 E. Latimer St., Tulsa, Okla.

Herman L. Cook, who has been at the University of Illinois is living at 327 N. Hazel St., Danville, Ill.

Sanford S. Cole gives 49 Jane St., Hornell, N. Y. as his address.

Robert M. Corl is now located in the National Supply Bldg., Huron St., Toledo, Ohio.

M. F. Cunningham writes that he is with the Waltham Grinding Wheel Co., Waltham, Mass.

John Fitzgerald formerly of Niagara Falls, N. Y. has moved to 572 Terrace Ave., Clifton, Cincinnati, Ohio.

M. S. Gifford who has been living at Libertyville, Ill., has recently moved to Lake Bluff, Ill.

Raymond Gilmore has resigned his position with the Laclede-Christy Clay Products Co., St. Louis and is living at 7710 Linwood Ave., Cleveland, Ohio.

A. F. Greaves-Walker, president of the AMERICAN CERAMIC SOCIETY, has moved to Stevens Pottery, Ga., where he has accepted a position as Vice-President and Manager of Operations with Stevens Brothers and Co., manufacturers of clay products. Mr. Greaves-Walker was formerly Production Manager with the American Refractories Co., at Pittsburgh, Pa.

Marshall W. Harris of the University of Illinois has secured a position at Ada, Okla.

J. W. Hepplewhite, recently of Manville, N. J. is with the Edwin M. Knowles China Co., East Liverpool, Ohio.

R. M. Howe has notified the Secretary's office that his address is 1120 Lancaster Ave., Pittsburgh, Pa.

Walter A. Hull who has been with the Bureau of Standards at Washington, D. C., has moved to Chicago, Ill., where he is associated with the Northwestern Terra Cotta Co.

Richard E. Jones of Tarentum, Pa. has moved to 620 E. Eighth Ave.

Harry J. Knollman asks that his mail be sent to 325 E. Ave. 31, Los Angeles, Calif.

George A. Loomis of Steubenville, Ohio is moving to 322 South Spring St., Los Angeles, Calif.

Gilbert McCall is living at 3018 K St., Sacramento, Calif.

George J. Openhym of White Plains, N. Y., is spending the summer at Scarsdale, N. Y.

R. I. Montgomery has moved from 1624 Niagara Ave. to 533 10th St., Niagara Falls, N. Y.

Carl Perg, formerly of Kalamazoo, Mich., is living at Des Plaines, Illinois.

B. S. Radcliffe has left the St. Louis Terra Cotta Co., and is now with the Northwestern Terra Cotta Co., Chicago, Ill.

Charles Rose of St. Louis has recently moved to 447 9th St., Niagara, N. Y.

Oscar Shearer is now living at 5 N. Karlov Ave., Chicago, Ill.

Vincent DeP. Schildmeyer of St. Bernard, Ohio, has moved to 6450 Kennedy Ave. Cincinnati, Ohio.

Dr. Felix Singer gives as his permanent address Berlin-Charlottenburg, Carmerstr. 18, Germany.

T. D. Tefft is now located with the Thurber Brick Co., Thurber, Texas.

Bruce F. Wagner of Ames, Ia., has moved to 3109 Home Ave., Berwyn, Illinois.

Alan G. Wikoff, Industrial Editor of "Chemical and Metallurgical Engineering," Chicago office is now in the New York office of the McGraw-Hill Co., 10th Ave. at 36th St.

B. W. Willson, ceramics student at Ames, Ia., is spending the summer in Galesburg, Ill.

J. A. Wilson of Elwood, Ind., has recently moved to Kittaning, Pa.

Harold G. Wolfram who has been studying ceramics at the University of Illinois is now with the Bureau of Standards, Washington, D. C.

AMERICAN CERAMIC SOCIETY SUMMER MEETING AUGUST 8, 9, 10, 11

TOLEDO—DETROIT—FLINT

Plant Visits

Glass House Refractories—Modern Machine Methods of making glass bottles, window and plate glass—Porcelain spark plug cores and assembled plugs—Enameled, steel and iron, common brick, grinding wheels, art pottery, and automobiles.

Pleasure Trips

Midnight on the Detroit river and Lake St. Claire. More tonnage travels on Detroit river than enters the metropolitan harbors, more than moves from New York, London, Hong Kong and Liverpool combined. The lake trips from Detroit are unsurpassed in scenery and comfort.

Belle Isle famous the world around as a park of beauty, refinement and educational opportunities; extensive aquarium, horticultural and zoölogical collections; concerts, boating, swimming motoring and casinos.

Headquarters

Secor Hotel, Toledo—August 8
Wolverine Hotel, Detroit—August 8, 9, 10, 11

Itinerary

August 8—	8 A.M.	Hotel Secor. Dr. H. W. Hess and A. S. Zopfi, committee in charge.
	12 M.	Complimentary lunch at The Toledo Yacht Club
	7: 25 P.M.	Leave on Michigan Central train 306
	9: 00 P.M.	Arrive Detroit (dinner en route)
		F. H. Riddle, Mrs. W. B. Stratton, H. F. Royal, H. S. McMillan, Jos. Hoehl, J. R. Kempf, committee in charge.
August 9—	9 A.M.	Chartered bus to Ford Motor Co. (experimental continuous pour plate glass plant) and Champion Porcelain Co. (Dressler Tunnel kiln operating at cone 18)
		Complimentary luncheon at Champions
	2 P.M.	Trips chosen by delegates
		Porcelain Enameling and Mfg. Co.

	Detroit Stove Works
	Wolverine Porcelain Enameling Co.
	Pewabic Pottery Co.
	Detroit Brick Plants
7:30 P.M.	Boat Ride—Dancing on deck
August 10—8:10	Leave by special cars for Flint
	T. G. McDougal, P. D. Helser and S. J. McDowell, committee in charge.
	A. C. Spark Plug Company (complete production and assembling of plugs), novel tunnel kiln operating at high temperatures.
	Buick Motor Co.
8:00 P.M.	Dinner with entertainment and dancing
	Hotel Wolverine
August 11—9:00 A.M.	Special bus to Detroit Star Grinding Wheel Co.
	River Rouge plants of Ford Motor Co.
	The Ford Steel plants
	Ford new plate glass plant
Week End	Lake trips as shall be chosen by the delegates.

COMMITTEES FOR ANNUAL MEETING OF THE AMERICAN CERAMIC SOCIETY

Atlantic City, N. J., February 4, 5, 6, 7, 8, 1924

Executive Committee

ANDREW FOLTZ, CHAIRMAN
R. H. Minton, Vice-Chairman
C. A. Bloomfield
Abel Hansen
Chas. Howell Cook
August Staudt
F. W. Dinsmore
D. P. Forst
R. R. Valentine
H. Mueller
E. C. Hill
H. K. Kimble
G. H. Brown, Secretary

Railroad Transportation

WERNER MALSCH, CHAIRMAN
Geo. W. Gilks
Chas. E. Jacquart

Hotel Accommodations

FREDERICK STANGER, CHAIRMAN
Hubert Somers
Chas. H. Lovett
D. W. Scannel

Publicity

L. R. W. ALLISON, CHAIRMAN
C. W. Hill
Franklin G. Lord

Service

C. F. GEIGER, CHAIRMAN
Robert E. Anderson
W. L. Howat
R. E. Long
John M. Kreger

Banquet

R. H. MINTON, CHAIRMAN
F. A. Whitaker
E. C. Hill
Frederick Stanger

Finance

G. H. BROWN, CHAIRMAN
C. W. Crane
E. V. Eskesen
August Staudt
C. S. Maddock, Jr.
M. M. McHose
D. R. Edgar
Abel Hansen

Reception

H. F. STALEY, CHAIRMAN
R. L. Clare
August Staudt
R. P. Hazlehurst
Otto W. Will

Entertainment of Ladies

MRS. G. H. BROWN, CHAIRMAN
Mrs. A. Foltz
Mrs. R. H. Minton
Mrs. E. E. Hill
Mrs. F. Stanger
Mrs. R. P. Hazlehurst

Trips

D. P. FORST, CHAIRMAN
Leslie Brown
John A. Williams
Chas. H. Kerr
Geo. Simcoe
O. O. Bowman, 2nd
G. M. Tucker
H. A. Plusch
G. E. Hoffman

Exhibit

IRA A. SPROAT, CHAIRMAN
K. E. Ward
John. P. Goheen
Eric W. Turner
C. T. H. Phillips

THE PITTSBURGH DISTRICT SECTION MEETING[1]

The meeting held on June 8, 1923, was called to order by Chairman, Professor A. Silverman.

Dr. E. W. Tillotson reported a balance in possession of the Finance Committee for the Silver Jubilee Convention. It was noted that this should be returned pro rata to the companies who had donated this money.

Chairman Silverman reported that the printing of stationery for the different Sections of the SOCIETY could be greatly simplified by having the new sectional and national officers take their office at the same time. It was voted that this report be received for future consideration.

The following committees were appointed to serve this year:

Program Committee: J. S. McDowell and F. C. Flint.

Entertainment Committee: R. M. Howe and H. G. Willetts.

Motion pictures of the Corning Glass Works were shown through the courtesy of J. C. Hostetter.

SUMMER MEETING OF THE NEW JERSEY CLAY WORKERS ASSOCIATION AND EASTERN SECTION OF AMERICAN CERAMIC SOCIETY

The Summer Meeting of the New Jersey Clay Workers Association and Eastern Section of the AMERICAN CERAMIC SOCIETY was held at the Trenton Country Club, Trenton, N. J., on Friday, June 29th.

The meeting was opened at one o'clock with a luncheon served in the ball room of the Club. Mr. Andrew Foltz acted as toast-master and a number of interesting speeches were given,—notable among which were those by Messrs. Charles Howell Cook, Chas. W. Crane, T. A. Randall, W. P. Blair, R. H. Minton and Thos. Campbell of Sydney, Australia.

[1] By H. G. Schurecht, Secretary Pittsburgh District Section, AMERICAN CERAMIC SOCIETY.

Following the luncheon a brief business session was held, President Andrew Foltz in the Chair. The following reports were then submitted for approval: Report of 1922 Summer Meeting, G. H. Brown, Secretary; Report of Executive Committee—R. H. Minton, Chairman; President's Report—Andrew Foltz.

Attention was called to the fact that the Eastern Section is to have charge of the arrangements for the 1924 Annual Meeting of the AMERICAN CERAMIC SOCIETY to be held in Atlantic City during February. President Foltz named the committees which have been chosen to make the 1924 Meeting a success in every way and one long to be remembered.

President Foltz announced the appointment of the following committee to be in conference from time to time with a committee of the Board of Trustees of Rutgers College concerning the work of the Ceramics Department:—

Abel Hansen, Pres., Fords Porcelain Wks., Perth Amboy, N. J.
H. A. Brown, Pres., Lenox, Inc., Trenton, N. J.
C. A. Bloomfield, Metuchen, N. J.
C. H. Cook, Pres., Cook Pottery Company, Trenton, N. J.
F. W. Dinsmore, Imperial Porcelain Wks., Trenton, N. J.

At the close of the business session, a very interesting paper entitled "The Application of Tunnel Kilns in the Firing of Ceramic Wares" was presented by Prof. Carl B. Harrop of Columbus, Ohio. Messrs. Conrad Dressler and T. G. McDougal contributed interesting discussions to Prof. Harrop's paper.

Mr. Chester C. Treischel, Secretary of the White Wares Division, AMERICAN CERAMIC SOCIETY, discussed "Feldspar Classifications and Specifications" and briefly outlined the work which the White Wares Division is doing.

At the close of the afternoon session it was found that a total of 110 members and guests had registered,—this being the record attendance at any Summer Meeting of the Section. A number of new members were enrolled and the meeting was voted a most successful one in every way.

AN EXPRESSION OF OPINION ON VALUE OF THE JOURNAL

M. R. Cuthbertson of Oroya, Peru, South America writes the following letter which is of unusual interest to the readers of the *Journal*.

"...As to the *Journal* let me say that I belong to another technical organization which costs me double the amount of dues for the AMERICAN CERAMIC SOCIETY and the monthly publication gotten out by this institute cannot compare with the *Journal* for technical value.

"The paper in question leans altogether too much to editorials written by men who cannot for some reason publish their writings elsewhere. For this reason we must wade through pages of pseudo-technical bunk in hope of sometime discovering something of use to us.

"I have no definite information, but I should judge that of all technical papers written perhaps one per cent of the information contained in them may be applied without much change. One paper, I remember well, for I combed it from beginning to end hoping to gain some information as to the hardness of the original material, the size, the content of moisture, or the size of the machines used. To me the paper was useless.

"This is not so with the *Journal of the American Ceramic Society*. Whether the writers are more practical, or whether they are simply better able to take in all angles of the subject, I cannot say. This much I know. I am making common, fire and silica

brick, and naturally am more interested in that line of ceramics than in the manufacture of glass, but I have been able to pick information of value to me in my line from a paper on the manufacture of glass in the *Journal*.

"When you consider that we are operating kilns at 12,000 and 14,000 feet altitude and lack of pressure and oxygen content produces problems in combustion, and that I can still get information of value on combustion from the *Journal*, I think we have good reason to think well of our contributors."

OBITUARIES

Arthur T. Beach

Arthur T. Beach, President of the Beach Russ Company, manufacturers of pumps, and President of the Abbé Engineering Company, manufacturers of grinding and pulverizing machinery, of New York, died at his home in Brooklyn, N. Y., on June 16. His death was due to heart failure. Mr. Beach was born in Connecticut in 1862. He founded the Beach Russ Company in 1891 and in 1912 became President of the Abbé Engineering Company. Mr. Beach is survived by three sons, all of whom were associated in business with him.

H. H. Preston

Word has been received of the death of H. H. Preston of Pittsburgh, Pa. Mr. Preston was employed with the J. W. Cruikshank Engineering Co., of Pittsburgh and was a member of this SOCIETY.

Haydn E. Vaughan

On account of the death of Haydn E. Vaughan, one of the younger members of the AMERICAN CERAMIC SOCIETY, his father Edward Vaughan, has asked that his membership be transferred to Willis C. Mellott, one of his classmates. Haydn Vaughan was a student at the University of Pittsburgh and lived at 7107 Mt. Vernon Avenue, Pittsburgh.

NOTES AND NEWS

PLASTICITY RESEARCH FUND AT LAFAYETTE COLLEGE

A letter to the Editor from Eugene C. Bingham, Professor of Chemistry, Lafayette College, Easton, Pa., states that the results of the work carried on during the past year have been so successful that he has made a contribution of $1200 toward the continuance of the work for another year. The full announcement of the character of this work on plasticity is found in the *Bulletin* **1** [11], 325 (1922). A report of the Research Committee of Lafayette College makes the following statement concerning this work.

"The plan this last year has been eminently successful, a large amount of information having been secured which will be published in due course. For example, a new method for measuring plasticity has been worked out which greatly simplifies the measurement of plasticity and reduces the time required to a tenth of that formerly required. As a result of this year's success, Lafayette College is ready to continue the present arrangement and $1900 has already been guaranteed toward the necessary $3600.

"It is proposed to continue the study of the fundamental problems of viscous and plastic flow, and it is hoped that the results may be applicable in flow connected with a single industry. The results of the researches will be made available through publication."

FUEL EFFICIENCY AT BRICK KILNS

Operators of numerous brick plants are putting into practical application the fuel-efficiency data obtained as the result of the series of burning tests at industrial kilns recently conducted by the laboratory car Holmes of the Department of the Interior, in coöperation with the heavy clay trade associations, according to reports submitted to the Bureau of Mines by its field agents.

A notable example has been reported to the Bureau from Birmingham, Ala., in the case of an operator of two brick plants near that city who had been operating his kilns without especial regard to modern, efficient methods. This operator, being a member of certain brick trade associations, receives through these associations the results of improved methods of burning as developed by kiln-burning tests conducted under the direction of the Ceramic experiment station of the Bureau of Mines at Columbus, Ohio. Against the advice of the old practical burner and everyone else connected with the work, the superintendent at one of the plants decided to try out the method as outlined by the tests made by the Bureau of Mines. The results were more than satisfactory. At this plant it formerly took about 9 days to burn a kiln with a consumption of over 1400 pounds of coal per 1000 brick. The company had contemplated building more kilns to take care of the demand. They now burn off the kiln in 5 to 6 days and use under 900 pounds of coal per 1000 brick. Instead of building more kilns, some of the other kilns are now idle, while the plant still maintains its capacity.

SUMMER MEETING OF THE PACIFIC NORTHWEST CLAY-WORKERS' ASSOCIATION

Driers and Drying

We invite drying specialists to come this way on their summer vacations to attend the summer meeting of the Pacific Northwest Clayworkers' Association held in Seattle, Wash., on August 25. *One big meeting* devoted to *one big subject* of vital importance to all clay manufacturers, in the *one big vacation* center of the country, in the vacation time.[1]

Seattle and the Puget Sound country furnish an ideal location for a summer vacation: Cool spring-like weather, salt water, fresh water lakes, snow-covered mountains, big deep cool forests, fishing, boating—any sport you wish; any variety of accommodations—metropolitan life in Seattle to camps on the beaches and mountains. Drive out in your car, visit the big clay plants of the Pacific Northwest and see the wonderful possibilities for future development in all branches of the clay and ceramic industry.

Our association has a membership of over 50 and is only 6 months old. 70 attended the last general association meeting and over 30 came to the Brick, Tile and Sewer Pipe Division Meeting held June 2.

[1] For particulars, address Hewitt Wilson, Secy.-Treas. U. of Washington, Seattle, Washington.

PACIFIC NORTHWEST CLAYWORKERS' ASSOCIATION[1]

Reports from Brick, Tile and Sewer Pipe Division Meeting

The program of the Pacific Northwest Clayworkers' Association on auger machines, lamination and brick-laying school work proved to be instructive, practical and of financial value to those who attended this meeting in June.

Mimeographed copies of Mr. Adderson's paper on lamination and die working and the ceramic department's 11 page outline of the same subject can be obtained from the office of the secretary, ceramic engineering department, University of Washington. The request from non-members of the association must be accompanied by 25 cents to cover the cost of the mimeographing and postage.

As a result of a resolution passed at the meeting, the following telegram was sent to the American Construction Council in the name of the Association:

Franklin D. Roosevelt, 120 Broadway, New York City: "We understand that the American Construction Council proposes to undertake a publicity campaign to stop new construction in all parts of the country for ninety days. We are not familiar with conditions in the East except from news reports such as *Literary Digest*, but understand that millions of dollars of work have already been indefinitely postponed. We feel that building is a basic industry and highly essential to national prosperity and delay at this time will result in a serious depression. In Pacific Northwest building is only beginning to revive after a number of years slump. We do not have labor shortage here and prices of building materials are not unreasonable. Our manufacturers, architects, contractors, builders and labor need work this year. Your proposed action will tend to drive our skilled mechanics to other occupations and to other sections and result in a permanent loss. If any warning is needed we feel that the publicity already given your proposed action is more than ample and we earnestly protest the continuation of such propoganda covering the country as a whole and the Pacific Northwest in particular. Our association is composed of manufacturers and employees of brick, tile, sewer pipe, terra cotta, pottery and other clay product industries of states of Washington, Oregon, Idaho and British Columbia. At meeting held yesterday a resolution was passed that this protest be wired to you." Pacific Northwest Clayworkers' Association, Hewitt Wilson, Secy.

We feel that it is imperative for us to unite all our efforts in encouraging building at this time and to resist movements of this kind which tend to discourage construction. Have the various organizations of your community sent in protests to the American Construction Council?

VOLUNTARY ADOPTION OF STANDARDS OF QUALITY

EDITOR'S NOTE:

Standards of Quality.—Much profit has resulted from standardization of size, shape and design. The elimination of unnecessary varieties has been practiced for a sufficient time and in a large enough number and varieties of industries to demonstrate it to be of vital economic importance. So it will be with standardization of quality.

On page 191 of the *Bulletin* section of June *Journal* appeared a communication on this subject from Julius H. Banner, President of U. S. Chamber of Commerce. His

[1] For a summary of Mr. Cook's work in his brick-laying school, address, Mr. C. W. Cook, 3135 Broadway North, Seattle.

statements rang so true that the material from which he drew his observations was sought and the following letter and data were obtained. This letter under date of May 22 was written by C. L. Ishleman of The American Malleable Castings Association to E. H. McCullough, Manager, Fabricated Production Department, U. S. Chamber of Commerce.

How the American Malleable Castings Association Establishes Quality Standards for the Products of Its Members

"This letter will reply quite fully to the recent *Bulletin* of the United States Chamber of Commerce under the caption 'Voluntary Adoption of Standards of Quality.'

"For more than ten years, The American Malleable Castings Association has been carrying on the work of quality standardization now so urgently recommended by Secretary Hoover and the Chamber of Commerce of the U. S.

The American Malleable Castings Association

CERTIFICATE

This Certifies that _____

has submitted daily test bars representing its product for the quarter ending _____ and that said product meets the requirements of the Specifications of the Association, the practice of said plant is such as to produce uniform material of high character and integrity.

Executed on behalf of the Association at Albany, New York, this _____ day of _____, 192__.

Attest:

"By coöperative effort and scientific research the malleable iron industry has really found itself, and is today recognized as one of the country's outstanding examples of what well directed Association effort can accomplish in producing a uniform product of the highest quality and integrity.

"As the voluntary establishment of quality standards has been the keynote of our Association effort for many years, we are in hearty sympathy with the Department of Commerce in their present effort to use this means of protecting consumer interests and take pleasure in giving you the following outline of our effort in this direction."

"Ten years ago, there was little definiteness to the physical properties of malleable iron and there were practically as many varieties as there were foundries making it.

"Every foundry had its own theories, many of which were based on meager and insufficient knowledge of the whole subject. The annealing process by which the casting loses its brittleness and takes on the valuable properties of malleability was accredited to reasons that later have proved erroneous.

"In fairness, it must be said that even at that time, there were a number of manufacturers who were striving independently to improve the quality of malleable iron by scientific study and research. Whatever discoveries were made by them were jealously guarded as trade secrets and the industry as a whole did not benefit. This policy proved a boomerang to the industry in that inferior castings still being made by old rule-of-thumb processes threatened to stigmatize all malleable castings regardless of quality.

"This was the condition prior to 1913 before scientific research and testing of materials through coöperative effort were begun.

"The American Malleable Castings Association, now made up of about sixty representative companies in this industry, at that time comprised about twenty-five members. This group determined to enlarge their field through coöperative action and to take certain, definite steps toward raising the standards of the industry. They decided

1.—To go the limit in the matter of metallurgical research regardless of cost, in order to make *uniform*, high-grade castings.

2.—To disseminate this scientific knowledge among all members so that the entire Association could make such castings.

3.—To see that every public statement regarding the progress should be conservative and that it should be accompanied by accurate data to substantiate it.

"At this time a Research Department was organized and Professor Enrique Toucedah an eminent Consulting Engineer of Albany, New York, was retained to carry on the research work of the Association. The veil of mysticism that had been woven about the production processes of some of the more successful foundries was lifted and the best from each was adopted.

"Since that time the Consulting Engineer has labored unceasingly to instruct members in sound plant practice and correct principles of manufacture. Thus it is seen that in the obtaining of business members of the American Malleable Castings Association are competitive, but in the improvement of their product, coöperative. Through research, the Association has become an instrument of service to all industries in which malleables are used and has raised the manufacture of malleable iron from a hit-or-miss proposition to a scientific basis."

Test Bars Submitted Daily by Every Member

"When the research work was started one of the first requirements was that each member of the Association submit test bars daily to the Consulting Engineer for an independent determination of tensile strength, elongation and other important physical properties. This practice not only shows the quality of each member's product, but furnishes data on which a comparison could be made of the product of the whole membership. Equally important, it also served as a direct and positive measure of the improvement in quality from month to month. This practice of requiring every member to submit test bars from daily heats, still continues and is supplemented by Inspectors, acting solely under the direction of the Association's Consulting Engineer who make frequent, unannounced calls upon member companies to check up the manufacturing processes, the product itself and in general to serve as a check upon the actual test on bars submitted by member companies. The test bar record thus reinforced by constant field investigation of plant methods may be considered as truly representative of the product."

Constantly Setting Higher Specifications at Which Members Could Aim

"At the time the research work was started, the specification of Malleable Iron of the American Society for Testing Materials called for a tensile strength of 38,000 pounds and 5% elongation in two inches. This specification while exceeding the product

of many of the foundries was, as later developed, far short of the possibilities of the metal when properly made.

"Through individual plant inspection the adoption of the more successful practices and the submitting of test bars regularly, it was not long until the majority of the plants were making a product that exceeded the A. S. T. M. specifications. Upon the direct solicitation of The American Malleable Castings Association the A. S. T. M. specifications were raised to 45,000 pounds tensile strength and 7½% elongation. This higher specification was later adopted by the S. A. E. and other technical organizations.

"Inspired by its success in constantly improving the quality of malleable iron and not content to 'leave good enough alone' the Association aspired to a still higher standing for the product of its members. The result is that a new specification of 50,000 pounds per square inch tensile strength and 10% elongation has recently been adopted and again the different technical societies will be requested to raise their specifications for malleable iron.

"This latest specification is 32% higher in tensile strength and 100% higher in elongation, than when the research was begun. During this same period, other valuable properties such as uniformity, soundness, rust-resistance, and easy machining have shown even greater improvement.

"It is doubtful if, in the entire history of American industry, there exists a similar instance of a trade association requesting that the leading engineering societies increase the rigidity of the specifications covering the product of its members."

The Practice of Issuing Quarterly Certificates of Merit

"As an incentive to greater effort toward improving quality, the Association a few years ago instituted the practice of issuing quarterly certificates of merit. As the awarding of a certificate for a given quarter is wholly in the hands of the Association's Consulting Engineer the only possible way in which one can be secured by a member is through rigid adherence to requirements in connection with physical tests and integrity of product during that period. Before a certificate can be awarded to a given plant, two general conditions must prevail:

1st, the test bars from each day's production sent to the Association's laboratories must have met the Consulting Engineer's requirements for tensile strength and elongation, and

2nd, the plant practice of the member during the same interval must receive the endorsement of the visiting Inspectors.

"Out of the practice of issuing certificates to members, came the idea of Certified Malleable Castings —the product of certificate-holding plants.

"While originally intended only as a reward of merit in foundry practice, the possession of a certificate has come to be a guide by which buyers determine the source of supply for their malleables.

"It is interesting to note that frequently members have striven for years to get their name on the published list of Certified Malleable producers, even going to the expense of rebuilding their plants and revamping their equipment and foundry practice in their effort to meet the Association's requirements for Certified Malleable Castings.

"If, for any reason, the product of any member falls below the established standards, for any quarter, the name of that company is omitted from the quarterly list of Certificate Holders and his name is also omitted from the list that is part of every magazine advertisement put out by the Association. Thus it can be seen that there is a real penalty imposed should a member become careless or indifferent.

"Copy of certificate issued to member companies is attached to this letter.

QUALITY STANDARDS AS DEVELOPED BY SOME TRADE ORGANIZATIONS

American Gas Assn.—Association nomenclature, material, specifications, abbreviations and performance specifications.

Associated Metal Lath Mfgrs.—Association has standards for weight, tolerance quality and gage.

Electric Power Club.—Association numbers among its principal activities the matter of quality of standardization.

Hollow Building Tile Association.—Association has standards for weights, sectional dimensions and tolerances. (Some of these standards are only in the recommendatory stage.)

National Paving Brick Mfgrs. Assn.—Association has standard specifications for wear and tolerances and standard methods of testing.

Portland Cement Assn.—Association has standard specifications for testing which have been adopted by the U. S. Government, American Society for Testing Materials, and others.

American Malleable Castings Assn.—One of the most outstanding cases of quality standardization. Tensile strength of castings increased from 38,000 pounds to 50,000 pounds. Elongation raised from 5% to 10%. Association maintains inspection and certification service.

Cement Products Assn.—Quality standards established and adopted. Association maintains test, inspection and certification service.

REPORT OF CONFERENCE ON SIMPLIFICATION OF HOLLOW BUILDING TILE

Elimination of 23 of the 36 prevailing sizes recommended

At a meeting held June 19, 1923, at the Department of Commerce, the Standards Committee of the Hollow Building Tile Association reported to the Department's Division of Simplified Practice, the results of a survey which the Association had made of existing varieties in types, sizes, and weights of hollow building tile.

The survey showed 36 different sizes—each made in a wide variety of weights. The Committee recommended the elimination of 23 of the 36 sizes, and the retention of 13 as "standards" for the industry. A standard weight, with a permissible variation of 5% over or under the standard weight, was also recommended for each of the 13 sizes retained.

The Committee requested the Department of Commerce, through its Division of Simplified Practice, to call a general conference next October of manufacturers, architects, engineers, contractors, and builders to discuss the general adoption and use of the recommended standard sizes and weights.

Those present at the meeting were: E. R. Sturtevant, Fraser Brick Co., Dallas, Tex. H. R. Straight, Adel Clay Products Co., Adel, Ia. H. C. Downer, Malvern Fire Clay Co., Malvern, O. P. H. Bevier, National Fire Proofing Co., N. Y. C. W. Dixon, Columbus Brick & Tile Co., Columbus, Ga. F. J. Huse, Research Engineer for the Association, Chicago, Ill. E. W. McCullough, Mgr., Fabricated Production Department, Chamber of Commerce of United States, Washington, D. C. Ray M. Hudson, Division of Simplified Practice, Department of Commerce.

This is another decided step forward in the Hoover plan to reduce the cost of building construction through elimination of waste in industry, Ray M. Hudson, the Commerce Department's representative at this meeting declared as the session closed.

CALENDAR OF CONVENTIONS

American Association of Iron and Steel Electrical Engineers—Buffalo, N. Y., September 24–28, 1923.

AMERICAN CERAMIC SOCIETY (Summer Meeting)—Toledo, Detroit and vicinity, August 8, 9, 10 and 11, 1923.

AMERICAN CERAMIC SOCIETY (Annual Meeting)—Atlantic City, Feb. 4, 5, 6, 7 and 8, 1924.

AMERICAN CERAMIC SOCIETY (Exposition Meeting); Wednesday, September 19, is Ceramic Day.

American Chemical Society (Fall Meeting)—Milwaukee, Wis., Sept. 10 to 14, 1923.

American Electrochemical Society (44th Meeting)—Dayton, Ohio, September 27–29, 1923.

American Face Brick Association (Southern Group)—West Baden, Ind., November, 1923.

American Gas Association—Atlantic City, October 15–20, 1923.

American Institute of Electrical Engineers—Del Monte, Calif., October 2–5, 1923.

American Society of Sanitary Engineers—Davenport, Ia., September 10–13.

Common Brick Manufacturers of America—Los Angeles, week of Feb. 11, 1924.

National Exposition of Chemical Industries—New York City, September 17–22.

National Safety Council—Buffalo, N. Y., October 1–6, 1923.

New York Hotel Association—New York City, November 19–24, 1923.

Power and Mechanical Engineers—New York City, December 3–8, 1923.

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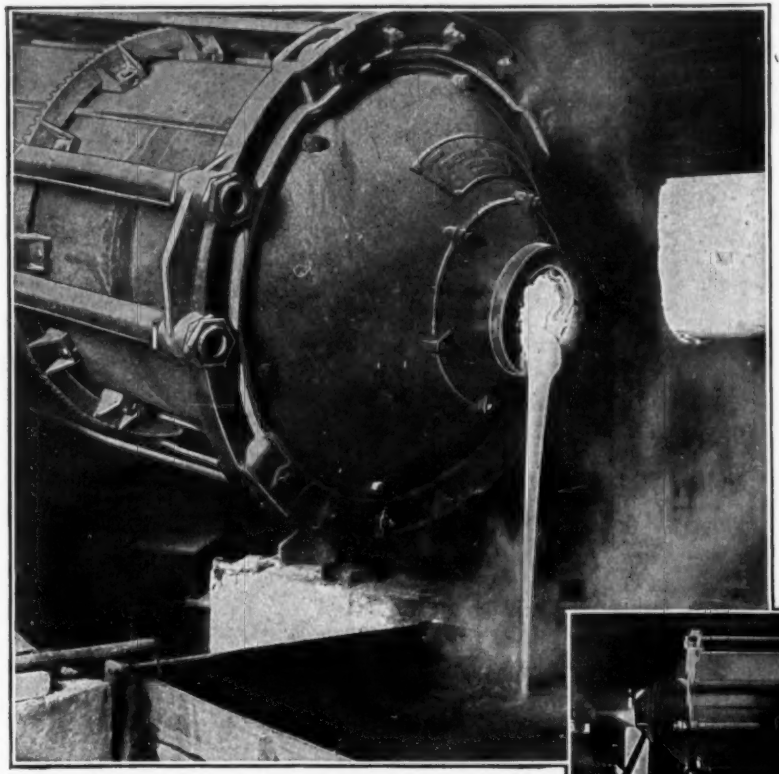

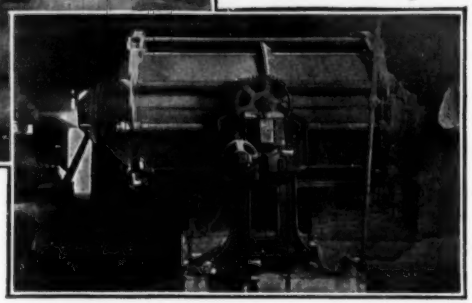

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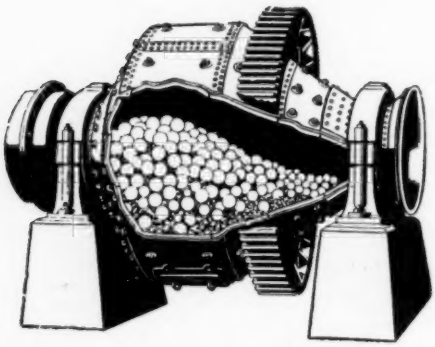

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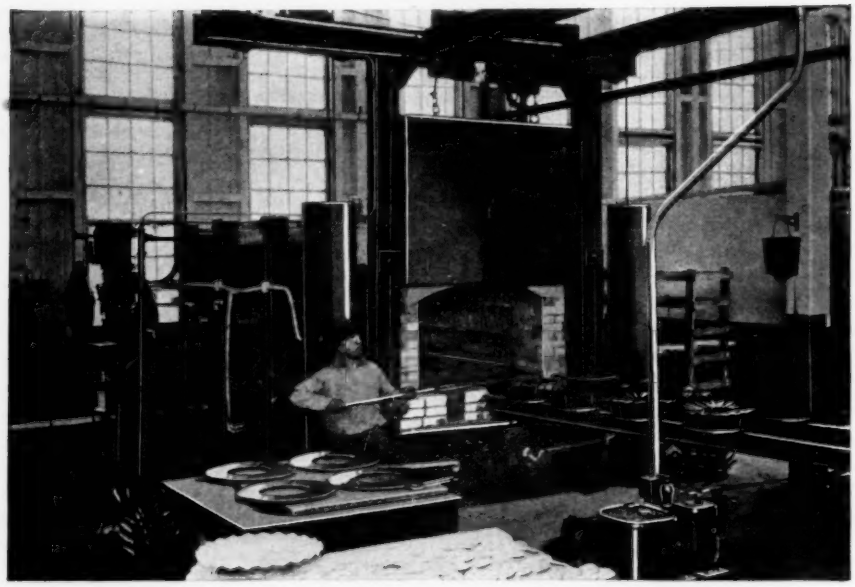

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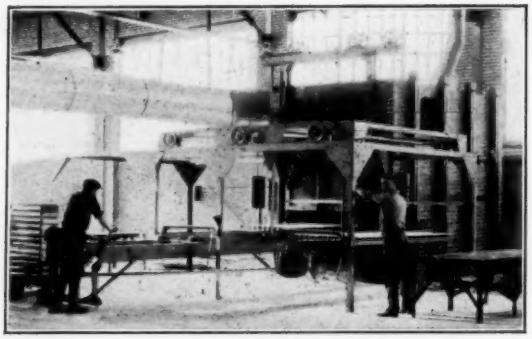

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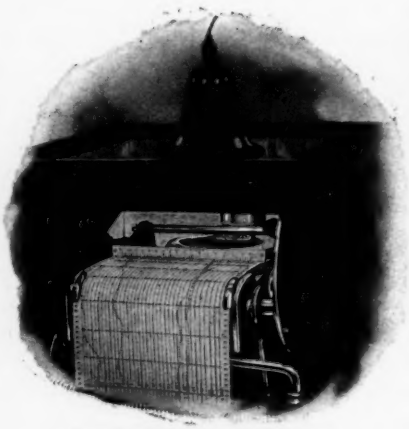

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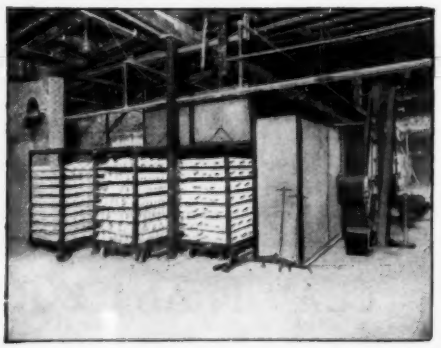

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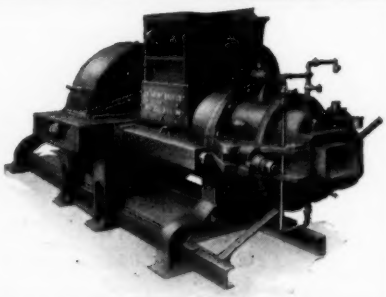

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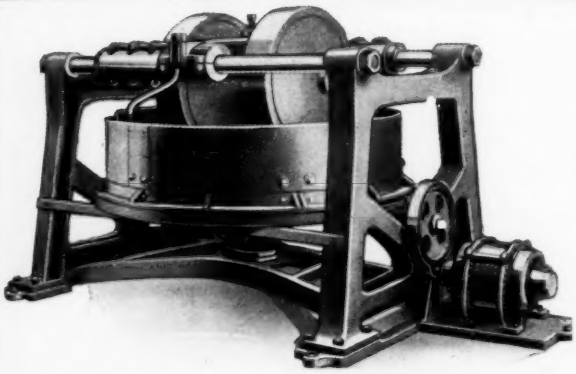

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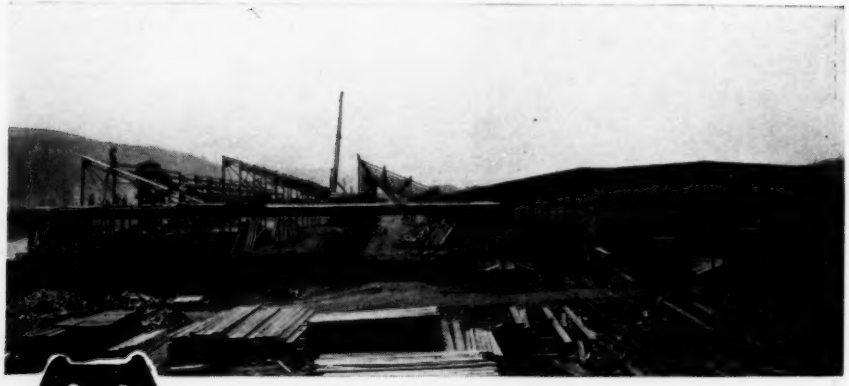

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